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SPECIAL OVERSIGHT REVIEW OF AGRICULTURAL RESEARCH AND DEVELOPMENT

REPORT

BY THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

AND THE

SUBCOMMITTEE ON DOMESTIC AND INTERNATIONAL SCIENTIFIC PLANNING AND ANALYSIS

(SPECIAL OVERSIGHT REPORT NO. 2)

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

NINETY-FOURTH CONGRESS

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LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C., August 31, 1976.

Hon. OLIN E. TEAGUE,
Chairman, Committee on Science and Technology, U.S. House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: Throughout a substantial part of the current Congress the Subcommittee on Science, Research and Technology and the Subcommittee on Domestic and International Scientific Planning and Analysis have been engaged in an extensive review of agricultural research and development. Our inquiry was devoted to that part of the R. & D. effort which is food-related. The interest of our two Subcommittees arose from our concern that American agricultural research should be brought to bear on future United States and world food needs. This work has been designed to accomplish the purposes and functions of Special Oversight as assigned to the Committee on Science and Technology by the House of Representatives at the beginning of the 94th Congress.

On June 28, 1976, we issued a brief interim report which sketched the activities of the Subcommittees in agricultural research as well as our tentative conclusions, findings, and suggestions for further considerations.

The report we are now transmitting is the final report based on the Subcommittees' activities up to this time. It includes a number of recommendations which we believe are important and which we hope will prove of value to all parties, public and private, who have a genuine concern for the improvement of agricultural research and development.

We wish to acknowledge the assistance in the preparation of this report from the Congressional Research Service of the Library of Congress, and particularly from Carol Lee McBee who assisted in the research and collation of parts II through VII and Appendix E, and from Elaine Carlson, who was responsible for much of the other appendix material.

We wish to emphasize that this report does not conclude the Subcommittees' interest in agricultural research nor preclude further activities in this area in the future. We commend the report to the attention of all Members and of the appropriate departments and agencies of the executive branch.

Sincerely,

JAMES W. SYMINGTON,
Chairman, Subcommittee on Science, Research and Technology.

RAY THORNTON,
Chairman, Subcommittee on Domestic and International Scientific Planning and Analysis.

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SPECIAL OVERSIGHT

Research and development is conducted throughout the Federal Government. Most agencies and departments support research and development to further advances in those fields of science and technology which are related to their mission.

In the House of Representatives these research and development activities are reviewed individually by a number of standing Committees having jurisdiction of the various programs, agencies, and departments. Beginning with the 94th Congress, the rules of the House provide that a continuing review of the entire Federal research and development effort be done. For this purpose the Committee on Science and Technology is charged with the function of Special Oversight in this area. Rule X, paragraph 3(f) provides that "The Committee on Science and Technology shall have the function of reviewing and studying, on a continuing basis, all laws, programs, and Government activities dealing with or involving non-military research and development." This Special Oversight function is to be performed in addition to the legislative and direct oversight function of the standing committees.

The review and the recommendations included in this report are made pursuant to this Special Oversight provision of the House rules.

ABBREVIATIONS

AID	Agency for International Development (Department of State)
ARI	Agricultural Research Institute
ARPAC	Agricultural Research Policy Advisory Committee
ARS	Agricultural Research Service (Department of Agriculture)
BARR	Board on Agriculture and Renwable Resources, (Natonal Academy of Sciences)
CGIAR	Consultative Group on International Agricultural Research
CSRS	Cooperative State Research Service (Department of Agriculture)
DOC	Department of Commerce
DOD	Department of Defense
DOI	Department of the Interior
DOS	Department of State
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ERS	Economic Research Service (Department of Agriculture)
ESCOP	Experiment Station Committee on Organization and Policy (State Agricultural Experiment Stations)
FCS	Farmer Cooperative Service (Department of Agriculture)
FCST	Federal Council on Science and Technology (National Science Foundation)
FDA	Food and Drug Administration (Department of Health, Education, and Welfare)
FS	Forest Service (Department of Agriculture)
GAO	General Accounting Office
HEW	Department of Health, Education and Welfare
MAPS	Management and Planning System (Agricultural Research Service, USDA)
NAS	National Academy of Sciences
NASULGC	National Association of State Universities and Land Grant Colleges
NIH	National Institutes of Health (Department of Health, Education, and Welfare)
NRC	National Research Council
NSF	National Science Foundation
OMB	Office of Management and Budget
OTA	Office of Technology Assessment
SAES	State Agricultural Experiment Station(s)
SRS	Statistical Reporting Service (Department of Agriculture)
TVA	Tennessee Valley Authority
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey (Department of the Interior)

RECOMMENDATIONS

Improved Policy Formulation, Management Structure and Coordination of Research

The Subcommittees on Science, Research and Technology and on Domestic and International Scientific Planning and Analysis find that the U.S. agricultural research system has no present equal and has served the country well in helping it to meet domestic and international food needs. These successes are evidence that the system is basically sound; however, as in any other area of human activity, the Subcommittees believe that the present agricultural research system would benefit from innovations in its management structure and in the procedures used to coordinate its research efforts. The Subcommittees therefore believe that careful consideration should be given to the following courses of action:

RECOMMENDATION 1

A Clearly Defined National Policy for Agricultural Research Should Be Established

Changes in the domestic agricultural situation and in the world food market have transformed both the politics of agriculture and the demands on agricultural research and development. The crucial role of agriculture in maintaining United States' leadership in world affairs demands productivity increases which are steady over the long term and not merely from one growing season to the next. The only means by which this goal will be achieved is through appropriate application of the results of agricultural science and technology. This requires thorough, long-range planning, and the policy and mechanisms to carry it out.

The agricultural research system in the United States is extremely complex, with many sources of support and a variety of performers. This diverse community, which shoulders much of the responsibility for the Nation's well-being, would benefit from guidance on critical policy issues related to the work it performs. Tradeoffs will always be necessary to fulfill the objectives of agricultural research within the prevailing economic, social and political framework. To aid them in making good decisions, agricultural researchers need the guidance which only a national policy can provide. Among other critical issues and questions the following need to be seriously examined, debated and subsequently presented in a coherent policy statement: What tradeoffs is this country willing to make between agricultural production, energy con-

sumption, materials availability, land use and environmental quality; between agricultural production, the survival of the independent family farm, and the preservation of rural life as it now exists; between agricultural production, improved nutrition and food safety? Within this framework, how can agricultural research best be conducted?

RECOMMENDATION 2

Individuals Qualified and Knowledgeable in the Agricultural Sciences Should Be Included at the Highest Levels of National Science Policymaking

The present isolation of agricultural science from the policymaking processes for the rest of the sciences should be changed. The principles embodied in our national science and technology policy cannot be adhered to nor effectively implemented under these circumstances, and this situation is detrimental to the country as a whole. Agricultural science must be treated as an equal partner with the other sciences in the determination of priorities among the sciences and in the formulation of policies affecting the conduct of research and and development.

To this end, exceptional agricultural scientists should be carefully considered for such positions as appointment to the Office of Science and Technology Policy in the Executive Office of the President, and membership on such bodies as the President's Committee on Science and Technology, the National Science Board, and the advisory panels of the Office of Technology Assessment.

The Subcommittees are aware of the long history which underlies the relative isolation of agricultural science from the other sciences, and recognize that reversing the trend will not be an easy task. Increased respect for each other's disciplines and increased interaction and cooperation among the sciences are ends that will not be attained merely by the inclusion of a few agricultural scientists in the upper levels of government. However, the implementation of this recommendation might well be a first important step in this direction.

RECOMMENDATION 3

The Leadership Role of the Department of Agriculture in the Conduct and Support of Federally Funded Agricultural Research Programs Should Be Examined

Criticisms have been levelled at the Department of Agriculture which suggest to some that any new or increased Federal investment in agricultural research should be provided to departments or agencies other than USDA. These criticisms specifically relate to the types of research supported, the quality of the research, and the overall interpretation of the mission of the USDA.

Certainly, the leadership role of the Department of Agriculture in supporting the bulk of the Federally funded agricultural research programs should be examined. This should be undertaken even though the record established by the existing system has been good and attempts to dismantle it or seriously weaken it appear to be unjustifiable.

The USDA-State Agricultural Experiment Station system has the resource base necessary for the effective use of additional funds. Such resources include trained and knowledgeable personnel, systems of communication, facilities, and established programs with relatively stable sources of support.

This leadership role does carry with it major responsibilities such as initiating changes that are necessary to insure the larger interests of the Nation as a whole, as well as fostering interagency cooperation. A willingness to discuss alternative strategies and the elements of constructive criticism from within and outside the system is an important aspect of such responsibility.

In addition, the role of the designated representative of the Department of Agriculture to the Federal Coordinating Council for Science, Engineering and Technology in bringing to the Council's attention problems and developments in agricultural research should be determined. The Department of Agriculture and all other agencies involved in food-related research should also be responsive to the suggestions of the Federal Coordinating Council relating to food research.

Better interagency coordination is a desirable goal, although it may be one very difficult to achieve. New approaches to this should be tried so that ways to link other agencies with the Extension Service and the Current Research Information System may be determined.

The need and desirability of maintaining a strong, pluralistic system of support for agricultural research is clear, and the opinions expressed above should not be interpreted to the contrary. The Department of Agriculture must provide guidance to, *not* direct, the conduct of agricultural research throughout the nation.

RECOMMENDATION 4

Improved Information Exchange Between the Public and Private Sectors in the Field of Agricultural Research Should Be Encouraged and New Ways To Improve Such Information Exchange Should Be Explored

The Subcommittees were presented with evidence that, despite the close ties between the USDA and agricultural industries, there is a need for improved coordination and communication among the public and private research efforts. This is an especially important area of concern both because of the crucial role of agriculture and agricultural research

in serving the long-term interests of the U.S., and because of the limited funds available for the support of research and development in general as a result of the current economic climate.

The President's Committee on Science and Technology, established by Public Law 94–282, has been instructed to consider needs for, among other things, improvements in existing systems for handling scientific and technical information on a Government-wide basis, including consideration of the appropriate role to be played by the private sector in the dissemination of such information. The needs of the agricultural research community should be considered as an important aspect of this study and of any others which may be planned by other policy groups within the Federal Government.

One suggestion made in the course of the hearings to improve coordination of public and private agricultural research was to include industry as part of the Current Research Information System. Proprietary problems, the difficulties involved in identifying the numerous industries performing such research and the diverse reporting and cataloging procedures which may be used by these performers may preclude industry's becoming a full partner with the USDA–SAES in such a venture. If it is impossible for industry to include its ongoing research efforts in such a system, however, much might still be gained by giving industry access to information on the current research which is being conducted by the publicly supported agricultural research system. The USDA should explore the feasibility of this suggestion and determine whether it may offer advantages in the near future, pending the development of a more complete system for all Federally funded research and development.

Higher Quality Research

Among the many findings reported in 1972 by the Committee on Research Advisory to the U.S. Department of Agriculture of the National Research Council, National Academy of Sciences (the "Pound Report"), one in particular has been frequently quoted: "that much of agricultural research is outmoded, pedestrian, and inefficient." The USDA–SAES system has responded in various ways and degrees to the recommendations in the Pound Report which were offered to remedy this allegation. (See part VI of this report.)

Without doubt, there is necessarily a certain lead-time between enacting managerial changes and detecting the effects of these changes on the performance of the system. However, after a period of three or four years this same criticism of the present agricultural research system is evident in much of the testimony presented to the Subcommittees.

Measuring the quality of research is a difficult, sometimes impossible, undertaking. This is especially true when the research covers a broad range from the very basic to the most applied such as in the case of agriculture. In carrying out its responsibility for examining the state of science and technology over the years, the Committee on Science and Technology has accumulated knowledge of and, it believes, some

insight into problems of this type. Relying on this experience, it is believed that a strengthening of certain elements of the existing agricultural research system will produce increases in the quality of the system's output. The following aspects are particularly important:

RECOMMENDATION 5

Competitive Procedures for the Award of Agricultural Research Grants Should Be More Widely Employed

Although formula funding is necessary for the maintenance of a strong system of agricultural research, productive research efforts above and beyond this base are encouraged by open competition for research funds. There are three characteristics of such a program of competitive grants that normally are important for insuring the support of the highest quality research:

First, the competition should be open to the widest variety of research institutions possible. This should include land-grant and non-land-grant public universities and colleges as well as private universities and colleges, private research institutes and other research organizations.

Second, research grant proposals should be subject to peer review. In its report on the peer review system of the National Science Foundation, the Subcommittee on Science, Research and Technology stated that it was fair to infer from the testimony presented during the hearings "that witnesses agreed almost unanimously that appropriate peer review procedures would tend to select for funding those projects at the upper end of the quality scale, however high or low the upper end might be." Testimony presented by witnesses during the hearings on agricultural research and development leads to the conclusion that this inference probably also applies to agricultural research projects. It is further likely that other findings and recommendations made with regard to the NSF would be applicable to the USDA. Systematic methods of ensuring that competent reviewers are identified and used regardless of institutional affiliation or geographical location should be devised. Reviewers should be drawn from the same variety of institutions as those eligible for support under the competitive grants program, and no single reviewer should be overused in relation to his or her abilities. In reviewing proposals for research of a more "applied" nature, the opinions of individuals outside the research community should be sought—e.g., farmers, consumers, industry representatives, and so forth—but care must be taken not to equate the quality of the proposed research with its perceived applicability.

Third, broad guidelines concerning the areas of research to be supported by such a program should be provided, but funds should not be earmarked either by the Congress or the USDA for very specific areas of research. There should be sufficient flexibility in the system to ensure that if an area of research suddenly becomes "ripe" and increased support would lead to major advances, funds can be shifted and made available.

RECOMMENDATION 6

"Special Reviews" and "On-Site Reviews" of State Agricultural Experiment Stations, Currently Performed by the Cooperative State Research Service, Should Be Strengthened and More Widely Used

"Special reviews" of research programs or problem areas identified for improvement by the director of an experiment station and the "on-site reviews" initiated by the CSRS provide a means for encouraging the performance of high-quality research at the experiment stations and at the same time aid in improving the coordination of Federal-State and State-State agricultural research efforts. Both these functions merit strengthening and an expansion of the reviews.

It is felt that one of the factors which has contributed most towards the effectiveness and success of these reviews is the utilization of highly qualified peer panels in the review process. Where appropriate, increased utilization of qualified scientists from outside the USDA–State Agricultural Experiment Station system should be encouraged. Increased communication and understanding among researchers and research administrators within and outside the USDA–SAES system should benefit both communities.

RECOMMENDATION 7

Research That is National in Scope or Which Requires Major Capital Investments Should Be Centralized When Appropriate

The complex, decentralized system which characterizes agricultural research in this country has the advantage of a built-in responsiveness to a wide range of problems and public needs, especially at the local level. The evidence indicates that local participation has contributed much to the overall strength of the system.

However, there are also needs which may be more "national" in scope or for which large capital investments need to be made in order to carry out a strong research program. In those cases where research might profitably be concentrated in a few laboratories best equipped to carry it out, this should be done.

Federal funding practices, while emphasizing national needs, must be carefully balanced so as not to push the State Agricultural Experiment Stations in directions which may impair their responsiveness to local needs. It may not necessarily be in the national interest for all research groups to shift their programs in the direction of broad, national research, particularly if resources valuable for the solution of other (and perhaps more local) problems are drained in the process. Since the Federal government performs less than one-third of the food-related agricultural research and is dependent upon

State Agricultural Experiment Stations and the private sector for the remainder, any large national effort must necessarily require the participation of these components as well as the Federal laboratories.

RECOMMENDATION 8

Excellence Among Members of the Agricultural Research Community Should be Given Recognition

The hearings clearly suggested that the esteem in which the agricultural scientist is held by other scientists and society is not as high as it should be, either here or abroad. This may be in part due to the average or perceived quality of the research, to the "mundane" or "earthly" nature of the research, or to the fact that much of the research is applied rather than basic. Whatever the causes, it is imperative that the successes of agricultural research and the accomplishments of individual researchers be made known to the broader scientific community and to the public.

Little gain will be made in enhancing the esteem in which the agricultural scientist is generally held if his colleagues and employers do not fully acknowledge his achievements. Ways to effect this should be fully explored. Furthermore it is necessary that the agricultural researcher be encouraged to advance professionally as a researcher, both in terms of rank and pay.

Isolation and Removal of Research Gaps

As interest in agricultural research has intensified over the past year or so, many groups and organizations have produced reports and recommendations on areas of agricultural research which are, in their opinions, receiving "inadequate" attention. Depending on the composition of the group, the skeptic may view such a report to be self-serving or, at best, highly subjective.

Nonethless, reports prepared by groups with extremely diverse interests have shown remarkable agreement on the current research trends and gaps. Testimony supporting many of these findings, presented by witnesses from a wide spectrum encompassing both the public and private sectors, has been convincing on the point that measures must be taken to eliminate these problems and prevent others. The following areas are of special concern:

RECOMMENDATION 9

Increased Levels of Support Should be Provided for Those Areas of Agricultural Research Which Are Needed to Meet Future United States and World Needs

The Subcommittees repeatedly heard that the following areas of research need increased encouragement and support, either

through the availability of new funds or through a reprograming of existing funds.

(*a*) *Research on basic biological processes.*—Research on three basic biological processes—photosynthesis, nitrogen fixation, and genetic improvement—may be seriously underfunded in relation to the benefits which would result from significant advances in understanding these processes. Increased funding for this type of basic research, which is directly related to the major mission of agricultural research, should be provided from new or existing sources of funds.

Communication problems were found to exist between agricultural scientists and the basic research community (as exemplified by those receiving support from the National Science Foundation) when discussing the need for more "basic" research in agriculture. This problem stems from the fact that there is not a clear separation, either in terms of substance or definition, between "basic" and "applied" research.

To make this point as clear as possible, it should be noted that the term "basic research" is being used here to mean fundamental, albeit purposeful, research, which is necessarily high-risk and often carried out at the molecular or cellular level.

(*b*) *Research on energy-considering and environmentally sound agricultural practices.*—The interrelationships among food, energy, and the environment are very complex. Agriculture itself may be defined as the process of converting the sun's energy into food and other fuels. Agriculture can also be regarded as the science of living things—the same "living things" which constitute parts of our natural environment. The manner in which agriculture is conducted will directly affect and be affected by the availability of energy and the need to consider the quality of the environment. There is perhaps no one more aware of these relationships than the American farmer; but although the agricultural research system has responded somewhat to these factors, it has yet to demonstrate a significant regard for them.

A thorough integration of energy and environmental concerns into the agricultural research system is vital for the assurance of long-term agricultural productivity. Alternatives to current agricultural practices need to be developed either for use in conjunction with existing methods or in anticipation of future developments in order to assure balance among agriculture, energy, and the environment.

(*c*) *Research on human nutrition.*—Nutrition research, and the subsequent education of the public on all aspects of human nutrition, is at a primitive level. Although the National Institutes of Health conduct a substantial program in nutrition research, the bulk of this effort is less directed towards primary human nutrient requirements (which

might prevent the occurrence of disease in many cases) than towards the relationships between specific nutrients (or lack thereof) and particular diseases.

The USDA has not considered nutrition research a primary mission in the past. Today, in view of the vast amounts of money which the Federal Government is spending on domestic and international food programs, this matter should be re-examined.

(*d*) *Research on high-yielding systems of agriculture and other types of research which would benefit small-scale farm operations.*—It appears that insufficient effort is being expended on research which would enable the smaller farm units to remain competitive with large-scale production units. Three major aspects of this problem justify this concern.

First, as stated throughout these observations, short-term production efficiency should not be the supreme goal of agricultural research. Likewise, efficiency itself is not the supreme goal of societal organization. Not only is the human being an important "resource" which must be considered in the trade-offs of various types of agricultural research, but it is for human welfare and because of human labor that the system exists in the first place. It would be dangerous both in this country and abroad to embrace the most "economic" solution at any particular time in history at the expense of other social values.

Since the energy- and capital-intensive agriculture so widely practiced in the United States today trades off manpower for other resources, an economic argument might also be made that in the long-run the small family farm may be more efficient than the large-scale mechanized units we have today. This economic argument is less important than the larger social and philosophical questions, however—the many social advantages of family farms are of genuine significance.

Second, such research is needed to advance the science of home gardening. The one Federal program specifically addressing home gardening is within the Bureau of Outdoor Recreation of the Department of the Interior. Considering the value of this activity for providing high-quality, low-cost food to millions of Americans, for educating numerous citizens in the science and the art of agricuture, and for instilling an increased respect for the sources of our country's abundant food supplies, the agricultural research community should recognize this opportunity to contribute actively to a larger effort.

Third, this type of agricultural research may provide one of the most effective means for solving the world food problem. Farms in many other countries, particularly in the less developed countries where food problems are most acute, are small by American standards. It is inconceivable that large-scale, mechanized agricultural methods can be transferred to small farms abroad due to economic, social and techno-

logical barriers. This is true for many of the same reasons discussed above with regard to small-scale American farmers, and also for reasons unique to the particular countries.
There are methods and techniques of small-scale, high-yielding agriculture which are available today both here and abroad. Some of these techniques are much more productive per unit of land than the large-scale U.S. agriculture, since other resources are traded off in favor of the farmer's labor. The transfer of such technology and the vigorous pursuit of other new technologies for these purposes are essential for meeting future U.S. and world food needs and for reducing world tension.

(*e*) *Research on climate, weather prediction and modification, and related information systems.*—Despite the increased sophistication and advanced techniques of modern agriculture, our food supply remains dependent on climate and weather. These are the most influential factors in the production of food, yet the current level of research effort does not adequately reflect such dependence. Increased efforts are required to reduce the vulnerability of our agricultural system to weather fluctuations and climatic changes.
Furthermore, climate and weather information must be made easily and readily available to the farmer so that he will be able to minimize undesirable effects of climate and weather and thus the risk of a poor crop. More extensive interaction between the Extension Service and the Weather Service might be a logical first step in this direction.

(*f*) *A complete inventory of soil and water resources to provide a data base for research and policymaking.*—The demands on land and water by agriculture, industry, housing and recreation require careful land-use planning in order to assure adequate food supplies in the future. Useful planning requires knowledge of what land and water resources are available and what the production potentials are in various areas of the country.
Remote sensing, computers and other advanced technologies offer new opportunities for the completion of on-going inventories and the development of world-wide inventory systems. Maximum coordination between the agencies involved in satellite technology, data gathering, and information dissemination both in the U.S. and abroad is vital to the success of these systems.

RECOMMENDATION 10

Basic Research Programs of the National Science Foundation Which Are Important to Agriculture Should Be Strengthened

As discussed above much of the basic research which is vital to the nation's agricultural research system is "mission-oriented." For this reason and others, major new investments

in this type of research can best be made through the existing USDA–State Agricultural Experiment Station system.

The basic research supported by the National Science Foundation, which is less concerned with problem-solving and more concerned with development of knowledge for its own sake, is important to agriculture in that all technological advances depend on the solid foundation which such research provides. The National Science Foundation should use funds that are specifically allocated to research on renewable resources in the Research Applied to National Needs program so as to best coordinate these efforts with those supported by the USDA. However, while it is not advocated that the NSF specifically allocate funds for basic research in agriculture, it is recommended that the NSF maintain strong programs in those areas of science which are important to agriculture.

In its report accompanying the bill to authorize appropriations to the NSF for fiscal year 1977, the Committee on Science and Technology recommended that the NSF, through the Federal Coordinating Council for Science, Engineering and Technology, continually assess the role it should have and the degree of support it should provide in agriculture-related basic research. This role should be consistent with the maxim that basic research should not be concentrated within the National Science Foundation but that the bulk of agriculturally important basic research will be assumed by USDA; it further recognizes that the NSF does have a balancing role in the entire Federal research and development program.

RECOMMENDATION 11

The Nation's Agricultural Research Effort Should Be Better Balanced Between Short-Term, Commodity-Oriented Programs and Long-Term, High-Risk Work

The agricultural research effort in the U.S. has been strongly oriented to a "commodity strategy"; that is, one based on incremental but reasonably certain improvements in the production of specific commodities. Although this approach has served the country well and has produced some substantial improvements in agricultural productivity, a number of commodities may be rapidly approaching their limits insofar as substantial increases in yields within the existing technological framework are concerned. It now appears that significant increases in productivity will only be obtained through major breakthroughs in agricultural research.

The USDA is, in its own words, aware that "there would be better chances for achieving the big breakthrough" under a "functional-discipline" strategy. This strategy recognizes that the same basic knowledge in a particular discipline, or the same basic functions, apply to a whole range of commodities or applications, frequently in a very similar manner. Such a strategy does, however, have a number of drawbacks and disadvantages.

Nonetheless, the USDA should undertake those risks which may be associated with such a research strategy, especially in situations in which the prospects for significant product improvement appear marginal following a commodity strategy. It is important to determine how widely such an approach might be adopted by the agricultural research community.

RECOMMENDATION 12

There Should Be An On-Going Evaluation of the Scientific Bases Which Govern Food and Agriculture Regulations

Much of the funding available for agricultural research in both the public and private sectors is used for meeting the requirements for nutrient labelling, food and human safety, pollution prevention and so forth in order to meet standards set by law and by regulatory agencies. Such regulations are made with the best interests of the American people in mind, and the research done to satisfy these requirements is valuable and deserves the emphasis which it is currently receiving. However, in order to make the best use of the limited funds available for research, it is extremely important, as new scientific information is accumulated relevant to existing or potential regulatory actions, that these regulations be re-evaluated in the context of the most recent and accurate scientific information. The Congress and the regulatory agencies need to be kept informed of such advances or changes in existing knowledge which might affect decisionmaking and the revisions of regulations or statutes.

Communication Among Researchers, Users of Research, and Consumers

Communication among the various organizations performing agricultural research is highly important for optimum expenditure of research funds and the avoidance of unnecessary duplication of effort. Communication with the world outside agricultural research is also essential to the agricultural research scientist, and ways to improve these channels of communication—in both directions—must continually be sought. Such outside audiences include other scientists not directly involved in agricultural research, farmers and businessmen who are the users of agricultural research, and the general public which is the ultimate consumer of the products of agricultural research.

The Cooperative Extension Service, an integral part of the agricultural research system, has been very effective in promoting the communication between agricultural researchers, and industry, farmers and consumers. The Extension Service has been perhaps one of the greatest strengths of the total system, and it should be considered a potential model for other information dissemination schemes.

In addition, agricultural scientists communicate with the scientific community at large through mutual participation in professional societies and through publication in scientific journals.

Numerous informal contacts among scientists also provide important linkages.

In this final category of recommendations to improve the ability of the present agricultural research system to meet future U.S. and world food needs, the following should be carefully considered:

RECOMMENDATION 13

Interdisciplinary Efforts, Especially Among Scientists and Basic Researchers Outside the Agricultural Research System, Should Be Encouraged

Efforts to bring together scientists from within and outside the agricultural research system and from a variety of disciplines related to agriculture should be encouraged and supported through the policies of the Federal agencies which fund agricultural research. Many of these interdisciplinary linkages evolve naturally, but funds to support such efforts would hasten this process substantially.

Workshops, conferences, symposia, and research projects involving a broad range of scientists can contribute to the growth of individual scientists and the reservoir of scientific knowledge. Additional investment in such activities by the Federal Government would be small in comparison to the potential benefits; hence the need for additional funds should be determind and specified.

RECOMMENDATION 14

The Conclusions and Proceedings of Conferences Relating to Agricultural Research Should be Made Widely Available and Utilized Where Possible

The concern of the Agricultural Research Policy Advisory Committee to involve a broad range of groups and organizations with interests in food supply and consumption in the formulation of priorities for agricultural research is encouraging. This concern was especially evident in ARPAC's having convened a National Working Conference on Research to Meet U.S. and World Food Needs in Kansas City, Missouri on July 9–11, 1975.

The results of major conferences such as these may be valuable, but only if they are widely disseminated among the various individuals and agricultural research organizations and considered in terms of their applicability to and implications for current and future research programs. The use of these results is the only justification for such conferences, and this use should be demonstrable.

At this time the followup on the Kansas City conference, which is being carried out by two committees appointed by the ARPAC co-chairmen, appears to be good. The degree to which those directly involved with the formulation of agricultural research policies use the results should be observed and studied.

RECOMMENDATION 15

Organizations Outside the USDA-State Agricultural Experiment Station System Should be Invited to Participate in Research and Extension Advisory Committees

The involvement of individuals outside the agricultural research system will no doubt bring fresh insights into the needs of the users of agricultural research and the consumers of its products. Where possible and appropriate the agricultural research community might extend invitations to selected representatives of farmers' organizations and consumer groups to participate in meetings of their advisory committees. Such involvement is desirable both for maintaining a research system which is responsive to the needs of the community it serves and for promoting a better understanding within that community of the problems that can or cannot be solved by agricultural research.

I. SCOPE OF THE HEARINGS

The field of agricultural research and development was given high priority for Special Oversight by both the Subcommittee on Science, Research and Technology and the Subcommittee on Domestic and International Scientific Planning and Analysis early in 1975. At the beginning of the 94th Congress which first charged the Committee on Science and Technology with the Special Oversight function, a joint effort of both Subcommittees to study this topic was begun.

This report of the two Subcommittees stems from the hearings held in June, September and October, 1975 and is based upon the oral and written testimony submitted during these hearings. Responses to the "Interim Report" on Agricultural Research and Development, published in June 1976, were used to supplement the hearing record and to refine the preliminary findings and tentative conclusions presented in that report. The national and international framework within which the Subcommittees conducted this Special Oversight review and the issues considered are outlined below.

The World Food Situation

After nearly two decades of increased food production during which many people took for granted the availability of sufficient food, stable or declining food prices, large grain stocks and large amounts of surplus food for food aid, the events of 1972 shocked many Americans into the awareness of the "World Food Problem." In 1972 world food production fell, and the decision of the Soviet Union to import massive amounts of grain to offset its losses and to cut back sharply on its usual exports of farm products was perhaps the single most important cause of the disturbances felt by Americans in that year. In 1972 Americans saw food prices rise sharply, food shortages develop, food aid shipments cut back, and grain stocks fall precipitously.

The Soviet purchases were not the only factor which produced this situation, however. Crop failures in other parts of the world, the decline in the Peruvian fish-catch, the U.S. farm policies of the late sixties, which held back crop production and eroded reserves, and the devaluation of the dollar are other commonly cited factors which also contributed to the disruptions felt in 1972.

Ever since Malthus published his "Essay on the Principle of Population" in 1798, there has been a fear "that the power of population is indefinitely greater than the power in the earth to produce subsistence for man." This fear has been heightened during times of temporary shortages such as those caused by natural disasters or war. Many view the present world food situation as a result of such temporary setbacks. Others believe that recent food shortages in various countries of the world are part of long-term trends which could well lead to increasingly severe global food problems. The most extreme point of

view is that Malthus' prediction of doom is imminent—a view which, fortunately, appears highly unlikely.

A number of leading authorities suggest that the "World Food Problem" is really one of certain developing nations, which implies that Americans should not be overly concerned about meeting domestic food needs in the future. In a sense this is true: it has been estimated, for example, that 94 percent of the people who are undernourished live in developing countries. Furthermore, although two decades ago the developing countries were exporters of grain, by the early 1960's these countries had become net importers of grain—and the magnitude of these imports has increased steadily since then. Increasing population, numerous problems of economics, and other factors all interact strongly and contribute to the existence and increase of hunger throughout the developing world.

Recent events, however, have clearly demonstrated that Americans can no longer consider the U.S. independent from the problems of the rest the world, nor consider this country to be totally self-sufficient. The oil embargo and the "energy crisis" highlighted the reality of our interdependence with other nations. Likewise, policy-makers are now considering the implications of our dependence on other countries for important nonfuel materials such as aluminum, chromium, manganese, nickel, tin and many others. U.S. farmers, on the other hand, need foreign markets for their products.

This interdependence in many fields therefore requires that all nations, including the U.S., rely on other nations for items essential for their individual economies or national security. It also implies that the internal problems of one country can have a great effect on many others. The increasing interdependence of all nations—both developed and developing—therefore necessitates viewing the world food situation as more than just an isolated problem.

The U.S. Role

The U.S. role in helping to meet future world food needs will depend on the American public's response to the demands of interdependence and on the policies that the Federal government pursues. There are many possible courses of action which could be pursued, but there are also several "non-solutions" which should be avoided. For example, mammoth shipments of U.S. farm products to other countries is not a solution: first, because the U.S. cannot produce enough food to take care of the needs of all its own people and the rest of the world; and secondly, because the responsibility for deciding where the food will be sent may lead to the use of food as an instrument of policy. More food must be produced everywhere, but especially in the developing countries themselves.

It has now also become commonly accepted that these future world food requirements can no longer be met simply by bringing idle land under cultivation. Although some estimates suggest that the world's cultivated area can be doubled, much of this land for potential cultivation is in the tropics. What limited experience is available has shown that once such lands are cleared for farming, their natural fertility often deteriorates rapidly. Much of this land is also in those parts of Africa and Latin America where the population density is low and where the costs of bringing this land into production would

be very high. In short, with a few exceptions, most of the world's highly productive farmlands are already under cultivation.

Increased food production must be sought through increased productivity, and this means applying the results of scientific and technological research to all aspects of food production. Few of the developing countries have the individual capability in terms of capital or manpower to mount large research efforts. The principal contribution of the United States to the world food problem in the long run may, indeed will, have to be through a sharing of our reservoir of technology to help other countries increase their agricultural production.

Previous experience has shown that there are numerous political, cultural, intellectual and economic barriers to effective technology transfer. U.S. support of and participation in the international agricultural research institutes has helped to overcome some of these barriers, as has our strong role in the extensive international programs conducted by the Food and Agricultural Organization (FAO) of the United Nations. But it is also true that our current level of understanding of agricultural production systems is least in those areas where the need is the greatest—in the environmental and social climates of the developing nations.

Implications

As important as the humanitarian reasons are for a strong United States' role in helping to meet future world food needs, there are other equally important reasons for making such a commitment. One of these is that a hungry world is not likely to be a peaceful world, and for this reason the long-term productivity of the American farmer and his foreign counterparts may be the determining factor in our pursuit of international harmony and world peace.

The export of agricultural products is also a major contributor to the maintenance of a favorable U.S. balance of trade. A statistic which clearly brings this point home to any American who felt the effects of the oil embargo is that in 1974 the export of agricultural products was enough to pay for four-fifths of our oil imports that year. Because of the importance of U.S. agriculture, then, it would naturally be expected that an increase in U.S. agricultural productivity will have domestic and international economic implications; and that, in general, any new U.S. role in helping other countries to better meet their own food needs will affect not only the economies of those other countries but the U.S. economy as well.

Some believe that the rest of the world has already become overly dependent on U.S. food supplies both in years of crop failures and in good crop years. As discussed above, these demands and pressures on the U.S. agricultural system are in turn felt by the American consumer. Because agricultural systems change very slowly, it is doubtful that this dependence (or perhaps over-dependence) will quickly disappear. It is much more likely that for some time the U.S. will remain the major source of food for those countries unable to feed their own people.

Maximizing U.S. agricultural productivity is therefore a highly desirable goal, and this will require a strong program of agricultural research and development and the rapid transfer of the results of

that R&D to the American farmer and to farmers in other countries. Thus one major question in any consideration of the world food situation and the U.S. role in it must be: "Is it sufficient to continue the kind of agricultural research and development activity that worked well in the past or does the future require something more?"

Defining the Issues

It was within this framework that the Subcommittee on Science, Research and Technology and the Subcommittee on Domestic and International Scientific Planning and Analysis joined in the search for knowledge and better understanding of the world's food system. The timing of the Subcommittees' involvement with this topic, while principally determined by the newly-assigned Special Oversight function, is significant in terms of the recent, high level of interest and activity in the subject of agricultural research and development and its relation to world food needs. Many other organizations and committees—both national and international, public and private—have been and continue to be involved in such undertakings.

The questions of "Why another group? What can these Subcommittees expect to contribute?" has legitimately been raised. In answering these questions the Subcommitttees rely primarily on the fact that the Committee on Science and Technology has long held broad responsibilities for examining the general state of science and technology, and in doing so has built up experience and some expertise in reviewing major programs having scientific content. Both Subcommittees wished to employ what knowledge they have accumulated in meeting these responsibilities in ways that would prove to be valuable for the Congressional committees and executive branch bodies involved in policy making for agricultural research.

Although the term "'agriculture" in common usage includes food, fiber, forestry and rural development, the two Subcommittees focused on the food question in these hearings. This inquiry was therefore undertaken in the spirit of broadening the information currently available about the agricultural research system in the United States, and particularly about those aspects of the system which directly relate to the production of food. The scope of the hearings included research and development relating to all food sources, whether plant or animal, and the application of research and development to all aspects of the food cycle, from production through processing, transportation, preparation and nutrition.

The hearings were not intended to focus only on the problems concerned with the governmental agricultural research establishment. Rather the Subcommittees attempted to achieve a balanced view of the entire system in hopes that recognition of the system's strengths would suggest ways to increase the overall effectiveness of national research programs in other areas of science and technology; and that this would also, perhaps, help other nations improve their own capabilities for increasing food productivity and nutrition.

One of the first witnesses during the hearings, Dr. Orville Bentley, cochairman of the Agricultural Research Policy Advisory Committee, expressed the intent of the Subcommittees well in stating that "the system works, but it is incumbent upon us to make it work better."

(I:p. 52) [1] Building on the strengths of the system will help to make it work better; however, such an approach can only provide a partial solution. After an examination of the system, particularly through the hearings process, the Subcommittees hoped to add to the work of others in offering constructive recommendations for improving the system.

In background papers prepared for these hearings,[2] Leo V. Mayer of the Congressional Research Service, Library of Congress noted that the findings and recommendations contained in previous reports on agricultural research can be categorized into four general areas of concern.[3] The Subcommittees chose to structure the issues examined during these hearings along similar lines. The four categories are: (1) improved policy formulation, management structure, and coordination of research; (2) higher quality research; (3) isolation and removal of research gaps; (4) communication among researchers, users of agricultural research, and consumers.

Among the numerous questions considered under the category of improved policy formulation, management structure, and coordination of research were:

> What are the national and international structures within which agricultural research and development are being conducted?
>
> Is a comprehensive formulation of a "national (or international) agricultural research policy" necessary, desirable and/or possible?
>
> Are the goals of agricultural research suffciently defined to determine priorities throughout the system?
>
> Are the resources available for agricultural research sufficient, and are they being efficiently utilized?
>
> What is the role and importance of the private sector in agricultural research, and is this research complementary or competitive with public sector research?

The maintenance of quality in research is a very important goal. Some of the issues surrounding the quality of agricultural research which were examined were the following:

> Do the funding policies of the Federal agencies encourage high-quality research?
>
> What aspects of the agricultural research system correlate with the promotion and performance of high-quality research?
>
> How does the broad scientific community perceive the quality of agricultural research in general, and what criteria should be used in forming such judgments of quality?
>
> Is the quality of scientific personnel engaged in agricultural research sufficiently high and, if not, how can it be improved?
>
> What steps can be taken to raise the status of those engaged in agricultural research?

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[1] References are to volumes I and II of the printed hearing record.

[2] U.S. Congress, House. Committee on Science and Technology. Subcommittee on Science, Research and Technology and Subcommittee on Domestic and International Scientific Planning and Analysis. Agricultural Research and Development: Background Papers. (Committee print) 94th Cong., 1st sess. September 1975. Washington, U.S. Govt. Print. Off., 1975. 179 p.

[3] Ibid., p. 32.

In attempting to increase agricultural productivity either in the United States or abroad, it is necessary that crucial areas of research be emphasized in proportion to their potential contributions. In considering the existence of research "gaps" and how best they can be filled, the Subcommittees addressed the following questions, among others:

Is there any consensus within the agricultural research community on areas of research that are currently underfunded or underemphasized?

What are the most important underlying causes for the existence of research "gaps" in agriculture?

What "non-agricultural" research activities are highly important to the agricultural research and development program?

What impact have the numerous regulations which affect agricultural food production and distribution had on the traditional patterns and priorities of agricultural research?

What types of research are being carried on by the private sector, and to what extent?

How much and what kinds of research being done in the United States have relevance to agriculture in other countries and vice versa?

One of the underlying causes of research gaps is poor communication linkages among researchers both within and outside the agricultural research community, the users of that research, and the consumers of the foodstuffs which are the product of that research. Some of the questions considered in this regard were:

What can be done to improve communication among those involved in agricultural research and in other facets of agriculture such as production, marketing and consumption?

What organizations should be involved in achieving expanded communications about agricultural research and development activities, and what responsibilities should be assigned to those organizations?

Are there problems with technology transfer which are unique to agriculture?

Is the agricultural research system responsive to new demands placed upon it by users and consumers, and are the users and consumers aware of the potential and the limitations of agricultural research?

Following a period of study on the subject of agricultural research, during which the issues outlined above were brought to light, the Subcommittees held eight days of hearings in Washington, D.C. and field hearings in three centers of agricultural research. As all these hearings were directed towards an examination of the agricultural research system as it relates to food, it is hoped that in the future additional special oversight hearings might be held on other aspects of agricultural research such as fiber, forestry, other renewable natural resources, and rural life.

II. THE ROLE OF AGRICULTURAL RESEARCH IN INCREASED FOOD PRODUCTION

In order to develop an accurate and precise picture of the agricultural research system in the United States, and of its potential ability to meet food needs, it is necessary to define the exact scope of such research, its limitations, and the way in which such efforts may be linked to increased or improved food production. The testimony of the witnesses and the extensive material submitted for the record by members of the research community provided ample basis for a discussion of these topics.

Defining Agricultural Research

The Assistant Secretary of Agriculture, Mr. Robert W. Long, appeared as one of the first witnesses in these hearings, and defined the scope of agricultural research for the Subcommittees:

> Agricultural research deals with the discovery, combination, and synthesis of knowledge essential to the continuing efficient production and marketing and the effective use of food, fiber, forest resources, clothing, and shelter under changing economic, social, and political conditions in the United States and the world; it deals with the protection of producers and consumers and with the wise use of natural resources; it involves the elucidation of a broad spectrum of public policy alternatives and consequences for people on and off the farms; and it includes research designed to add to basic knowledge that will advance these aims. (I: p. 41)

He went on to state that scientists of many disciplinary backgrounds including physical, biological, economic, social and political, would be involved in the agricultural research process. (I: p. 41) Long also suggested that many variables must be considered as part of the agricultural research process: "Climate: physiographic conditions; soil characteristics: water quality and availability; types of vegetation, livestock, and pests—including genetic variability within species." (I: p. 164)

Congressman Fred Richmond, a member of the House Agriculture Committee, testified that, not only does agricultural research have many facets, it also affects a great many activities or processes in the daily lives of people:

> Agricultural research affects the availability of food products, the cost of food, the nutritional quality of food, the availability of energy, the development of alternative energy sources for use in urban settings and contributes to the wholesomeness of the urban environment as well. (II: p. 401)

The Subcommittees intended the hearings to focus on the food-related aspects of the agricultural research system. Chairman Symington explained this in his opening remarks at the second set of hearings and defined the elements he considered to be part of agricultural research:

> It is our preliminary view that agricultural research should be directed both toward: securing an abundant supply of high quality, inexpensive and nutritious

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food for the citizens of this country and for the rest of the world, and achieving the general improvement of the quality of rural and urban life.

Agricultural research is involved in all aspects of production, processing, packaging, transportation, storage, and distribution. Between the appropriation or allocation of funds for agricultural research and the achievement of its goals are dozens of institutions within which scientists are engaged in basic research, applied research, technological development, and the extension of results. (II: p. 3)

Limitations on Agricultural Science

The complexities of the agricultural research system, with its many facets, its interdisplinary approach, and its many potential impacts must be recognized in any discussions of that system. Suggestions for improvements, critical comments, or even meaningful praise of such a system cannot be made unless the nature of agricultural science is understood in its entirety. In background papers prepared for the hearings by the Congressional Research Service of the Library of Congress, it was pointed out that:

Research and development in the agricultural sciences involve changing growth processes in living organisms—specifically plants and animals. Changes are difficult to create and hard to control. The vast majority of potential improvements in one facet result in diminishment of some other feature of the plant or animal world. Diethylstilbestrol (DES) is a good example. The gain in efficiency of feed fed to beef animals was eventually discounted by the potential hazard to humans of cancerous side effects. The lapsed time between discovery and recall was nearly two decades, however.[1]

Clearly, it must be considered that the response-times to new trends or rapidly changing national priorities may well be system-limited in terms of the complexities of agricultural research. The Subcommittees attempted to keep such limitations in mind during the course of the hearings and in this subsequent analysis of the materials and testimony which had been received.

The Link Between Agricultural Research and Increased Food Production

USDA witnesses provided much of the evidence which linked the advance of agricultural technology to any future increases in food production. Assistant Secretary Long, for instance, supplied the following statement for the record:

Major change in productivity will occur when new major technology is developed and adopted. It will also result from the accumulation of small incremental gains achieved over a period of years. . . . Estimating the availability and impact of major new technology is inexact at best. Some developments occur quickly, others came as the results of decades of systematic effort. (I: p. 184)

There have been some recent statements in the literature which indicate that the United States is not keeping up with the demand for new technology needed to continue increases in food productivity. Faced with expanding populations, worldwide, this would seem a dangerous and highly unfortunate situation. One of these claims appeared in a recent issue of Science magazine:

. . . that the trend in yields on [seven] experimental farms remained level in the decade of the 1960's can be explained by the absence of any breakthroughs in technology. The simple fact is that farmers are consuming technology faster than it is being produced by research.[2]

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[1] Op. cit., Mayer in Background Papers, p. 31.
[2] Thompson, Louis, Science, v. 188, n. 4188, 9 May 1975; p. 537.

A 1974 report of the USDA had also supported this idea, stating:

. . . for the future, minor technologies will contribute a modest improvement in productivity, but major change will have to wait the discovery of new major technology.

In his testimony Long discussed the possible reasons for the slowdown in technological developments after the spectacular successes in the first half of the 20th century:

Another factor needs to be recognized in the discussion of developing technology. As agricultural production becomes more sophisticated, dramatic breakthroughs are more difficult to achieve. Furthermore, an increasing proportion of research and development effort must be devoted to such things as new varieties simply to maintain current levels of productivity. Therefore, unless there are significant increases in support for agricultural research a lower proportion of the available resources can be devoted to new or additional improvements in productivity. (I: p. 184)

A representative of the agricultural science community, Dr. Sylvan Wittwer, chairman of the Board on Agriculture and Renewable Resources (BARR) of the National Academy of Sciences, also expressed the urgent needs in agricultural research in order to meet the technological demands for the future:

There is the urgency for a reassessment of national and global priorities and strategies in agricultural research. We cannot abdicate this responsibility to others. This Nation is, and must remain, the center of action for meeting world food problems. We have gone through an environmental movement, and now have keen awareness of the importance of protection, preservation, and conservation of our nonrenewable resources. We are now in the midst of an energy crisis and worldwide inflation. Here food and energy have many linkages, including price. We have more people on the Earth, and the numbers are increasing more rapidly than ever before in history. There is little indication that in the immediate future this will change. Any progress in the reduction of birth rates will be more than compensated for by increased life spans. There is no acceptable alternative except to seek agricultural victory in food production. Our productive capacity reserves include not only land, water, energy and fertilizer, and labor-saving equipment, but technology that can yet be created through agricultural research investments. (I: p. 21)

Dr. Sterling Wortman, of the Rockefeller Foundation, expressed his belief during the hearings that research was the key to the expanding world food problem. He suggested that the United States is faced with a "magnificent opportunity" to deal effectively with the problems of hunger and poverty, but noted that the Government must have the "will and the wisdom to act." (II: pp. 17–18)

In 1975 a conference of agricultural scientists, administrators, and policymakers met in Kansas City to discuss the research efforts required to meet United States and world food needs. The results of that conference were presented during the hearings. Although more detail on that conference is presented later in this report, the major theme is worthy of note here. It was that research is desperately needed in some key problem areas, including the field of human nutrition, crop production, use of natural resources and plant and animal disease and pest control. The conference participants felt that if these research needs were not met shortly, the United States could not provide the lead technology for its own food needs, much less the food needs of the rest of the world.

Dr. Karl Mattil, a professor of food production research with the Texas A. & M. University, felt that aspects of food research other than those normally clasified as productivity-related should be given

greater emphasis in future efforts to increase the supply of food. His statement presented the following premise:

> . . . that food science and engineering are probably the most economical approaches to increasing food supplies in terms of utilization of nonrenewable resources, and holding the line on food prices. They merit your careful evaluation and support. (II: p. 348)

A representative of the private sector, Dr. Richard Aldrich, president of the Agricultural Research Institute, also expressed the opinion that the only way to insure increased food production was through research efforts. He indicated that the United States should take the lead in providing the basic research efforts in relation to food, while developing countries could handle the more applied research necessary to meet their individual needs:

> I believe one of the challenges we face as a nation in meeting world food problems is in providing the linkage between so-called basic and applied research. Much of the latter, out of necessity likely will need to be done by the developing nations themselves. (II: p. 234)

Thus, representatives from all major segments of the agricultural research community seemed to agree that expanded and carefully directed research would be necessary in order to insure expanded food production in the United States and the world.

III. PARTICIPANTS IN THE SYSTEM FOR FOOD-RELATED AGRICULTURAL RESEARCH

The agricultural research system in this Nation is highly complex, with many sources of support, including major funding from the Federal Government. In order to examine the strengths and weaknesses of the system as it exists today, it was necessary for the Subcommittees to explore in detail the organization, management and funding of food-related agricultural research in the United States. This chapter is a compilation of all the material testified to or submitted for the hearings record that bears on the organizational aspects of the national agricultural research system, as it relates to food.

The USDA-State Organizations Involved in Food-Related Agricultural Research

Much of the agricultural research in the Nation is conducted or administered by five of the six research agencies of the USDA, the 55 State Agricultural Experiment Stations (SAES), the 15 schools of forestry, and the 16 land-grant colleges of 1890. (See Appendix A for a chronology of legislation and events in agricultural research and Appendix C for a listing of these academic institutions.) A sixth agency of the USDA, the Cooperative State Research Service, has as its primary function the administration of Federal funds for agricultural research at the State Agricultural Experiment Stations, the schools of forestry, the land-grant Colleges of 1890, Tuskegee Institute, and private institutions. The five USDA agencies performing agricultural research are: The Agricultural Research Service (ARS); the Forest Service (FS); the Farmer Cooperative Service (FCS); the Economic Research Service (ERS); and the Statistical Reporting Service (SRS).

By far, the largest portion of the food-related research is handled by the ARS, which conducts basic, applied, and developmental research in the following areas: Soil, water, and air resources; pest control; crops; livestock; environmental quality; food and nutrition; consumer services; rural and international development; food safety; health hazards related to agricultural processes; and domestic and export marketing. T. W. Edminster, the administrator of the ARS, noted that all of the above mentioned subject areas "are a part of the Department's missions." (II: pp. 68–69)

The Economic Research Service (ERS) carries out a smaller program on research related to food production and marketing. Robert Long observed:

> ERS programs deal with food and fiber economics and resource and development economics. Included are studies of foreign demand and competition and foreign development, the latter to aid agricultural development in lower income countries. (I: p. 46)

The ERS is also concerned with natural resources as they impact on food production. Therefore, ERS has conducted such studies as: The

impact of elimination of pesticides and herbicides; the impact of energy shortages; and surveys of the United States to determine how much land is available for crops. The results of ERS research projects are widely used by the USDA, other government agencies, the Congress, farmers, industry, and the general public to gain information on the national economy, as it relates to agriculture, the international economy, and on major commodities.

The Statistical Reporting Service (SRS) gathers statistics on farm production, supply, farm prices and other aspects of the agricultural and food systems. A very small portion of the total SRS budget is used for research activities on the methodologies used in gathering such statistics. Since these data play such a vital role in the functions of food production, the research conducted by the SRS on statistical methodology is included in this report as food-related.

The Farmer Cooperative Service (FCS) conducts or supports research activities in cooperative financing arrangements to improve the efficiency of farm operations. Additionally, FCS has been concerned with studies of the following items: grain, livestock, fruits, vegetables, farm supply efficiency, byproducts of cotton, cooperative development, dairy, and transportation and distribution of farm produce.

The Cooperative State Research Service (CSRS) within the USDA does not conduct any agricultural research but is responsible for much of the Federal grant money that goes to the State Agricultural Experiment Stations (see list, Appendix C) at the land-grant universities. Therefore, the CSRS has a significant impact on the food-related research that is conducted in the United States. The CSRS is also involved with the granting of funds to the 16 Colleges of 1890, and Tuskegee Institute. (See list, Appendix C.) Approximately two-thirds of the research done by these colleges would be considered food-related.

The four USDA agencies which conduct food-related research, and the other (CSRS), which administers contracts for food-related research, are under two different assistant secretary level positions within the USDA. The ARS and the CSRS are under the Assistant Secretary for Conservation, Research, and Education, while the ERS, SRS, and FCS are under the Director of Agricultural Economics.

The following sections describe more fully the organizational details of each of these agencies within the USDA.

AGRICULTURAL RESEARCH SERVICE

The Administrator of the Agricultural Research Service (ARS), Mr. T. W. Edminster, testified on September 24, 1975 about the specific programs and organizational aspects of that agency. He stated that the ARS is geographically decentralized into four regions [1] and 27 areas and centers, a programmatic division which allows for maximum contact with the needs and special problems of the various regions of the United States:

> ARS has laboratories and other experimental facilities in every basic physiographic region of the United States. This puts scientists and administrators in frequent and direct contact with users of research information and problems

[1] Northeastern, North-central, Western, and Southern. Each has a deputy administrator.

where they occur, and also in day-to-day contact with our State experiment station colleagues. (II: p. 72)

The ARS in fiscal year 1975 supported 9,300 personnel who were involved in approximately 2,900 separate research projects at 145 locations. Edminster noted that the ARS programs were linked to the missions and goals of the USDA, and occurred in the areas of domestic and international programs.

The ARS has recently undergone a programmatic reorganization designed to improve that agency's response to national research needs in the field of agriculture. The main change was the introduction of a management and planning system (MAPS), which:

. . . provides a framework for setting goals and objectives, allocating resources, providing technical leadership and optimizing the opportunities [for] job satisfaction for our employees. (II: p. 69)

The program structure which evolved from this MAPS system (discussed in detail in part IV) includes the following elements (II: pp. 94–97):

National research programs: The ARS has 67 such programs, each of which is linked to the missions and goals of the USDA;

Special research programs: There are eight of these programs which were not fully explained in the testimony.

The administration of the MAPS system involves the following staff elements of the ARS:

National program staff: Four assistant administrators [2] of the ARS and the Director of the International Programs Division in the ARS form this staff. Each of the national research programs are assigned to one of these people, who are responsible for planning, documenting, and coordinating the research. Each of the special research programs are also assigned to a member of the national program staff for administration.

Technical program staff: Approximately 250 of the top ARS research scientists have been assigned to assist the national program staff. In addition to their duties in the research area, these advisers have a responsibility to:

. . . promote and foster scientific excellence and technical advice to national program and analysis staffs for developing programs and conducting long-range planning and program assessment. They also . . . because they're in the field working closely with other research groups, provide a very excellent technical relationship with other research workers. (II: p. 70)

Work reporting units: The research programs have been divided by location into appproximately 1,000 of these units. The reporting and detailed planning for individual research projects are accomplished on this level.

ECONOMIC RESEARCH SERVICE

Perhaps the most important of the research functions performed by the Economic Research Service (ERS) relating to food would be:

—The development of national and worldwide estimates of current food use and the distribution of food;

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[2] The four assistant administrators are as follows: Livestock and Veterinary Sciences; Plant and Entomological Sciences; Soil, Water and Air Sciences; and Marketing, Nutrition, and Engineering Sciences.

—Identification of the interrelationships among economic forces, institutions, and Government policies and programs which can affect food:
—Development of short-term forecasts and long-range projections of the distribution of food for probable and future events;
—Evaluation of the performance of the food sector in meeting the needs and wants of consumers and the goals of society on related matters;
—Identification of the probable and possible structural adjustments in the food sector and evaluation of the impacts of such adjustments on all segments of society; and
—Distribution of economic information on a timely basis for use by individual consumers and decisionmakers in the food sector.

The ERS, in 1975, had approximately 1,050 employees, of which 550 were researchers. Most of these employees are located in the Washington, D.C., area, but a good portion (about 20 percent) are located in other States and in foreign countries.

The two broad areas of food and fiber economics and resource and development economics provide the core programmatic goals for the ERS. These two areas are divided into programs as shown below:

—Food and fiber economics: (1) commodity economics; (2) national economic analysis; and (3) foreign demand and competition; and
—Resource and development economics: (1) natural resource economics; (2) economic development; and (3) foreign development.

Within each of the six divisions mentioned above there are major program areas [3] headed by program leaders. A program area may contain a number of individual research topics, each of which will be headed by a project leader.

STATISTICAL REPORTING SERVICE

According to Assistant Secretary Long (I: p. 46), the Statistical Reporting Service (SRS) is concerned with the development of important statistical techniques used in gathering and evaluating statistical data. In general, the primary function of the SRS is to compile "timely surveys to develop estimates of farm production and supply, farm prices, and other aspects of the agricultural and food system. SRS also performs research in statistical methodology, data processing techniques, and methods of gathering and evaluating statistical data." [4]

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[3] Commodity economics: Commodity programs and policy analysis; fibers; grains and feeds; oil crops; fruits, vegetables, sweeteners, and tobacco; meat animals; dairy; and poultry. National economic analysis: Agricultural history; technology and innovation in the food and fiber sector; structure and adjustments; inputs and finances; transportation; sector performance measures; economic projections and analytical systems; pricing, policy, and program analysis; consumer economics and demand analysis; and distribution analysis. Foreign demand and competition: Developed countries and agricultural trade policy; weather and climate; Latin America; Africa and Middle East; Asia; Eastern Europe; Soviet Union; Communist Asia; commodities; statistics; international money and finance; and economic development and trade. Natural resources economics: Agricultural resources and environment; rural resources and environment; resource inventory and use; resource organization and control; resource projections and analytical systems; and resource program studies. Economic development: Housing, industrial location; health and education; regional analysis; State and local government; income; manpower; population; and rural development indicators. Foreign development: International training and technical assistance.

[4] Gilbert, George N., and Leo V. Mayer, "Agricultural Research: Men, Money, and Institutions." The Congressional Research Service, Library of Congress, July 1975.

Although the SRS has a fairly large effort in the area of data compilation which relates to food and food production, the only research it performs relates to the statistical methodologies utilized in data collection. It is estimated that approximately 1 to 1½ percent of the SRS effort is devoted to such research activities and, therefore, can be considered food related.

FARMER COOPERATIVE SERVICE

Robert Long stated that the Farmer Cooperative Service (FCS) deals with "studies of financial, organizational, legal, social, and economic aspects of cooperative activity in U.S. agriculture." (I: p. 46) Less than 100 employees perform the duties of the FCS in a central Washington office. No field offices are maintained by the FCS.

COOPERATIVE STATE RESEARCH SERVICE

The Cooperative State Research Service (CSRS) has the following functions, described by Robert Long:

> The Cooperative State Research Service (CSRS) administers formula (Hatch and McIntire-Stennis Acts) and special grant programs (Public Law 89–106) in support of programs in State institutions. CSRS provides assistance to the research administrators in coordinating research among the State institutions and between them and the Department of Agriculture. This assistance includes participation in long-range program development, at each institution, in regions, and nationwide. (I: pp. 46–47)

The CSRS functions are carried out by approximately 80 employees located in Washington, of which about 35 are scientific specialists.

Although the CSRS does not actually perform agricultural research, its impact on those who can carry out such research is significant. The CSRS has been delegated the authority of the Secretary of the USDA to administer Hatch Act funds, which provide a considerable amount of the funding for research at the State Agricultural Experiment Stations and at other institutions (see section on "Funding" in Appendix E).

As related by Dr. Thomas Ronningen, Associate Administrator of CSRS, the Hatch Act states that the Secretary of the USDA shall:

> "Furnish such advice and assistance as will best promote the purposes of this Act, including participation in coordination of research initiated under this Act by the State agricultural experiment stations, from time to time to indicate such lines of inquiry as to him seem most important, and to encourage and assist in the establishment and maintenance of cooperation by and between the several State Agricultural Experiment Stations, and between the stations and the United States Department of Agriculture." (II: pp. 130–131)

As far as the activities of the CSRS go, the Service felt that previously much of their time had been devoted to assuring compliance with the legal requirements of the Hatch Act in their funding of research projects. However, this has changed, as noted by Ronningen:

> . . . experience has shown that less time and resources are needed to insure compliance than in early years of the Hatch Act. Therefore, the agency now devotes the major part of its efforts to help improve total programs at client institutions and to help facilitate coordinative Federal-State and multistate research activities. (II: p. 134)

The CSRS necessarily maintains a great deal of information on existing research projects due to the nature of its functions. In 1966, a new system was instituted in the CSRS to track on-going research, the Current Research Information System. Ronningen stated that about 13 CSRS employees were involved in the maintenance of this computerized information system.

The link between the CSRS and the State Agricultural Experiment Stations is very strong. Ronningen noted that the Administrator of the CSRS is a member of the Experiment Station Committee on Organization and Policy (ESCOP) and that CSRS officials participate in all of the regular meetings of the four Regional Association of Experiment Station Directors.

STATE AGRICULTURAL EXPERIMENT STATIONS

There are 55 State Agricultural Experiment Stations (SAES), of which 53 [5] are under the management of the land-grant colleges of 1862. The Hatch Act of 1887 had provided for the establishment, in each State or territory, of a department of the land-grant institution to be known as the State Agricultural Experiment Station. Although the SAES are not a part of the USDA organizational structure, the cooperation between the USDA and the SAES is extensive, as evidenced by the substantial interaction between the SAES and the Cooperative State Research Service (CSRS), Agricultural Research Service (ARS), and other agencies. An SAES is typically part of a college of agriculture within a larger university structure. An important strength of the SAES system, as seen by Dr. Orville Bentley, a representative of the policy advisory mechanism of the USDA, is that there "is local direction of the program by the station director within the college of agriculture and the land-grant college." (I: p. 47) Dr. Bentley further observed:

> The typical agricultural experiment station is one of three branches of a college of agriculture in the State land-grant university. It involves a wide array of biological, physical, and social science disciplines. The other two branches of the college are concerned with resident instruction and cooperative extension. The experiment station, the primary agricultural research organization of its State, is supported by funds from several sources—State taxes, Federal funds through the USDA and granting agencies, and grants from private industry and foundations. (I: p. 48)

The organizational structure of most SAES includes an administrative head who reports to the dean or vice president with the responsibility for that college. Departments within the college can be classified into fields of science, such as biochemistry, genetics, or agricultural economics, or into commodity-oriented topics, such as agronomy, animal science, and food science. Usually both types of departments will be found in the same college. A department head will typically be responsible for general program direction in the three

[5] The Connecticut State Agricultural Experiment Station is not associated with a university. It was established under State initiative in 1875 prior to the legislation of 1887 which allowed for the formation of an SAES at each land-grant university in each State. Since Connecticut did have a land-grant university, this meant that the State acquired a second SAES under the auspices of that legislation. The SAES in Geneva, New York is also somewhat autonomous from the land-grant system. Although the director of the SAES does report to officials of Cornell University, which happens to be the land-grant university for New York State, this is not done under the terms of the Act of 1887.

areas of research, resident instruction, and extension. Dr. Orville Bentley, Co-chairman of the Agricultural Resetarch Policy Advisory Committee (ARPAC), noted that "the research function of the typical experiment station is closely intermeshed with resident instruction and extension; in fact, the same scientist is often involved in at least two of those functions." (I: p. 48)

Dr. Bentley observed that the input of scientific expertise from the USDA is also an integral part of the SAES research system since:

> USDA researchers are located in many university departments and work cooperatively with those departments. These scientists often carry joint titles with the USDA and the university, and many have graduate students or teach seminars or advanced graduate courses. (I: p. 48)

In 1975–76 there were approximately 26,000 professional workers in the SAES and cooperating state institutions.

Other Federal Organizations Involved in Food-Related Agricultural Research

Nine other Federal organizations conduct, administer, or support food-related agricultural research. The following chart outlines the organizations, the specific agencies involved within the organizational structure, and their research concerns. The research listed encompasses both basic and applied research directly related to food, as well as research more peripherally related to the topic. Detailed information on these activities can be found in II: pp. 1019–1132.

OTHER FEDERAL ORGANIZATIONS INVOLVED IN AGRICULTURAL RESEARCH

Organizations	Agencies	Program areas/research concerns
Department of State	Agency for International Development: Technical Assistance Bureau.	Reducing problems of food production in developing nations: Economic and sector analysis and planning for agricultural and rural development. Food crop production. Water and tropical soils management. Livestock production. Network of international research centers. Low-cost nutritious foods. Reaching the pre-school child (nutrition). National nutritional planning.
	Bureau of International Organizational Affairs.	Coordinating budgets for Food and Agriculture Organization and World Health Organization.
Department of Commerce.	National Bureau of Standards	Preparing standard reference materials for fertilizers, leaf analysis and oxygen permeation for food wrappings. Performing studies to improve salmon productivity in hatcheries. Making determinations of moisture in grains. Performing studies of the problems of development and clearance of new pesticides.
	National Oceanographic and Atmospheric Administration National Marine Fisheries Service.	Stuyding biological life sciences, chemistry, and economics which relate to fisheries as a source of food.
Department of Defense	U.S. Army Natick Development Center and Letterman Army Institute of Research.	Conducting research on nutrient effectiveness, processing and storage, and radiation preservation.
Department of the Interior.	U.S. Geological Survey: Topographic Division. Earth Resources Observation Systems Program, Geologic Division, Water Resources Division.	
	Fish and Wildlife Service	Performing studies on fish disease prevention and control.
	National Park Service	Examining the causes, effects, and control of natural fires.
Department of Health, Education, and Welfare.	National Institutes of Health	Supporting projects in nutrition research:
	Food and Drug Administration: Division of Nutrition. Division of Consumer Studies.	Food products Biochemical and metabolism studies. Nutrition associated with diseased states. Nutrition education.

OTHER FEDERAL ORGANIZATIONS INVOLVED IN AGRICULTURAL RESEARCH—Continued

Organizations	Agencies	Program areas/research concerns
Environmental Protection Agency.		Exploring the possible impacts of agricultural and food processing activities on environmental quality: Food products industry. Alternate pest management. Health and ecological effects fo pesticides. Effects of pollutants. Agricultural pollutant control.
Energy Research and Development Administration	Biomedical and Environmental Research. Solar energy.	Investigating plant sciences and the safety and wholesomeness of irradiated foods. Fuels from biomass. Agricultural and industrial process heat. Wind energy.
Tennessee Valley Authority.		Conducting research on fertilizers.
National Science Foundation.	Directorate for Biological, Behavioral, and Social Sciences.	Funding projects involving: Agricultural crops; growing or processing plant or animal products, food fiber, forest or fish, or their pathogens. Nonagricultural species, at the organism level, with some relevance to agriculture. Biological processes at the suborganism level, with some underlaying relevance to agricultural matters.
	Directorate for Atmospheric, Astronomical, Earth, and Ocean Sciences.	Investigating environmental forecasting.
	Directorate for Research Applied to National Needs.	Supporting projects on: Organic farming. Alternative beef production systems. Environmental control of effluents. Weather modification. Analyses of world grain reserves.
	Directorate for Scientific, Technological, and International Affairs.	Supporting: Research on the constraints on agriculture. NAS study on world food and nutrition. Project in mathematical dynamic simulation modeling of agricultural production.

Other Universities and Colleges With Agricultural Research Programs

There are at least one hundred universities and colleges outside the State Agricultural Experiment Station (SAES)/land-grant institution/Colleges of 1890 system which have on-going research efforts relating to food and agriculture. In some cases the programs may be quite small, in other cases the efforts are extensive and may well rival the program size at some of the SAES-affiliated universities. The American Association of University Agricultural Administrators (AAUAA) undertook a survey of these research efforts in 1975. They found that a variety of organizational units existed, including some colleges of agriculture, some divisions or departments of agriculture, and so on. In view of this diversity of reporting units, it is not possible to state a common organizational theme for the agricultural research systems in these academic institutions.

The National Association of State Colleges and Universities estimated recently that the non-land grant institutions graduate 20–25 percent of all the agricultural scientists in the United States. Clearly, the contribution of these academic institutions to the future of agricultural research in the United States, in terms of trained manpower alone, is extensive.

Nonprofit Organizations Involved in Food-Related Agricultural Research

Representatives of the Rockefeller Foundation and the Midwest Research Institute testified at the hearings on food-related research

activities currently supported by those organizations. To supplement that testimony, information was obtained from the Ford Foundation, the Kellogg Foundation, the C. F. Kettering Foundation and the Boyce Thompson Institute, selected because of their substantial involvement with the support of food-related research programs.

THE FORD FOUNDATION

The Ford Foundation supports research activities focused on agriculture in the developing countries in five major program areas: production technology; policy and planning; educational institutes; community development; and extension. A Foundation spokesman, Dr. Lowell S. Hardin noted that:

> For the most part, grants are made directly to institutions overseas. Only rarely do we fund an agricultural research project which is carried out exclusively in the United States. U.S. institutions are sometimes involved, however, in the execution of the research and training in overseas locations. (II: p. 1145)

The potential impact of the Foundation's support for foreign research could be significant for the world food situation. Additionally, Hardin believes that benefits could accrue to U.S. agricultural scientists since the development of professional competence and institutional capacity in overseas locations has made it "possible to conduct collaborative international agricultural research of a quality which previously was impossible." (II: p. 1146)

THE ROCKEFELLER FOUNDATION

The Rockefeller Foundation provides funds for food-related research under the auspices of three separate programs: Conquest of hunger, quality of environment, and equal opportunity. Under the conquest of hunger program, which performs the largest portion of agricultural research, grants and aid to U.S. universities are provided so that foreign students may study agricultural sciences and perform research useful to their homelands. The Foundation also provides extensive support to international agricultural centers through the Consultative Group on International Agricultural Research (CGIAR) as part of this program. Recently, the Foundation established the International Food Policy Research Institute "to carry out research and current policy analysis on problems affecting the production, consumption, availability, and equitable distribution of food throughout the world, but particularly in the developing nations." [6]

Although the emphasis is on international agricultural research needs, the Foundation does provide support for domestic research projects on pest management research, nitrogen fixation studies, and examination of cooperatives to further the agricultural sciences.

THE MIDWEST RESEARCH INSTITUTE

The Midwest Research Institute is a nonprofit research organization located in Kansas City, Missouri. The Institute performs contract research for Government, industry, and other public and private

[6] Rockefeller Foundation. The President's Review and Annual Report, 1975. New York. p. 15.

groups. Past work has included: the development of soluble, edible film for food packaging; research on environmental pollution problems relating to agricultural activities; water quality studies; research on toxic substances, including pesticides; economic studies of market expansion, transportation and distribution of agricultural products, and product diversification, and technology assessments of developments in agriculture.

In the past year the Midwest Research Institute sponsored a series of public forums called "Mid-continent Perspectives" which allowed industry leaders to discuss the major problem areas confronting their particular segments of the food system. The results of these seminars have been published and widely distributed to increase public awareness of critical issues relating to the food system.

THE W. K. KELLOGG FOUNDATION

The W. K. Kellogg Foundation is located in Battle Creek, Michigan. Projects related to food research are sponsored both domestically and internationally in such areas as: reindeer husbandry in Lapland; livestock and alfalfa production improvements for American Indians; irrigation efficiency studies for Navajo Indians; establishment of the Norwegian Food Research Institute for food science programs; and a program in Australia to provide a forum for decisionmakers in agricultural policy.

The funds utilized by the foundation are entirely internally generated. The Annual Report for 1975 stated that:

> A grant-making organization, the Foundation does not operate programs. It provides financial assistance to organizations and institutions that have identified and analyzed problems and have designed constructive action programs focused on practical solutions.[7]

THE C. F. KETTERING FOUNDATION

The C. F. Kettering Foundation supports food-related research in nitrogen fixation and photosynthesis at its own Yellow Springs laboratory in Ohio. The nitrogen fixation research activities are intended to develop new, synthetic systems capable of fixing nitrogen with less stringent requirements. The goal of the photosynthesis research is to improve the efficiency of photosynthesis processes and to improve the relationship between photosynthetic and nitrogen-fixation processes.

The mandate of the Foundation is to involve itself in problems of societal importance. It was established in 1950 and had not been particularly agriculturally oriented in the past. In recent years, the Foundation has concentrated its research efforts on more mission-oriented, unidirectional research. Although the efforts of the Foundation are presently funded entirely from endowment funds, the Foundation has recently made some efforts to obtain funding in the form of grants from various agencies and hopes to achieve some success in this area in the coming years.

A small program of extramural funding from the Foundation is utilized by U.S. universities to study the relationship between agriculture and climate. The Foundation also supported a research symposium

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[7] W. K. Kellogg Foundation. 1975 Annual Report. Battle Creek, Michigan. p. 41.

on "Crop Productivity—Research Imperatives" recently. In the fall of 1976 it will sponsor a conference in Spain on nitrogen fixation, and it intends to support similar conferences on a continuing basis every other year.

THE BOYCE THOMPSON INSTITUTE FOR PLANT RESEARCH

The Boyce Thompson Institute for Plant Research is a nonprofit institute located in Yonkers, N.Y. The program at Boyce Thompson Institute concentrates almost exclusively on food-related research and is supported approximately half from endowment funds and half from grants. The Boyce Thompson Institute is not a grant-making organization.

The Boyce Thompson Institute has four separate program areas or divisions: Environmental Biology; Cell Physiology and Virology; Physiology or Parasitism and Forest Biology; and Biological Chemicals. The research of the institute focuses on the areas of crop productivity, disease and parasite control, environmental effects on plants, seed physiology, and development of specific chemicals for pest and weed control.

The purpose of the Boyce Thompson Institute is "to learn through research how to improve the productivity of plants so they can better serve the needs of people everywhere." [8]

Private Industry Involvement in Food-Related Agricultural Research

It was difficult to get a clear picture of the extent of private industry involvement in food-related agricultural research during the testimony portion of the hearings. Dr. Richard J. Aldrich, a representative of the Agricultural Research Institute (ARI), apppeared but noted that:

> . . . the Agricultural Research Institute is not a research funding and a research managing organization. It is simply an association of organizations that are doing research. We are not underwriting research. . . . ARI was established to provide for communications on research matters between managers of research in the private sector and the public sector and between the private sector and the Agricultural Board of the National Academy of Sciences. The ARI still serves a very important primary role in these areas. But it is not research supporting of and in itself. (II: p. 257)

The ARI had 150 members at the time of the hearings, of which 99 were private industries and associations. Aldrich did feel that the private sector portion of ARI membership "tends to emphasize foods, feeds, machinery and agricultural chemicals," (II: p. 229) so that at least the major portion of these 99 could be considered as involved in food-related research efforts. That organization had conducted a survey of industry efforts in agricultural research in 1967. The report indicated that a list of 825 organizations deemed "large enough to be capable of significant activity in agricultural research and development" had been compiled by the ARI. Of the surveys sent out to these private organizations, only 252 responses were received.

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[8] Boyce Thompson Institute for Plant Research, Inc. 52d Annual Report, 1975. Yonkers, New York. p. 2.

(II: p. 1137) Table 6 in that report (II: p. 1140) listed the type of research interests reported by those who had responded. Approximately two-thirds to three-fourths of the responding organizations could be considered directly involved with or related to food. This might indicate that as many as 600 (if nonresponses are included) or as few as 200 organizations are involved in food-related research efforts in the private industry sector. The ARI survey in 1967 had concluded that roughly 50 precent of the agricultural research capability in the United States was represented by private industry, and Aldrich, the president of ARI, noted that "although this data has not been updated, I think it is fair to assume that the relationship likely is roughly today what it was 10 years ago." (II: p. 230)

It was also stated by Mr. Adolph Clausi during the hearings that the National Science Foundation had conducted a survey in 1973 which identified 125 companies in the private food industry sector which were conducting significant research. (II: p. 265)

Industry involvement in research efforts in food or food-related areas is frequently oriented toward product improvement with the intent of reducing costs. But the diversity of research efforts undertaken by private industry is exemplified by the statement of Clausi, a representative of a large food company, who noted that:

> . . . 600 of our 1,000 scientists and technically trained people in our organization worldwide are engaged in scientific work in the areas of basic research on food and nutrients, new product and process development, nutritional improvement of our products, process improvement of our processes, quality assurance, and compliance with government regulations. (II: p. 263)

Although a complete picture of private industry support for food-related research could not be obtained, the few statements made during the hearings and presented above indicate that the level of effort is relatively high, and that the results of such research could have a significant impact on the ability of the United States to meet future food needs.

International Organizations Involved in Food-Related Agricultural Research

In addition to the many foreign universities and institutions involved in agricultural research efforts, there are a number of organizations which play an important role in such research programs, either through the granting of extensive funds, the management of such grants, or the actual conduct of research in foreign countries. A brief outline of the major organizations involved is presented here.

Consultative Group on International Agricultural Research

This group, CGIAR, is an international consortium which was organized in 1971 with the primary goal of increasing food-crop production in the developing world through research. CGIAR is cosponsored by the World Bank, the United Nations Development Program, and the Food and Agriculture Organization (FAO) of the United Nations. In 1975 the group had a total membership of 33 governments—including the United States—international organizations, and private foundations. Since the time of its founding the number of research projects supported by CGIAR has increased from 4 to 12. The main

support from CGIAR goes to international agricultural centers. These are treated individually below. In 1976 operation of the newest of these centers, the International Center for Agricultural Research in Dry Areas (ICARDA), is expected to begin. The annual report of the World Bank for 1975 says of ICARDA:

> This center will devote its research to some cereals (e.g., barley), some grain legumes (e.g., lentils), and to farming systems centered on sheep and goats, with particular attention to the problems of areas with low and irregular rainfall. When the center is established and begins its work, probably in 1976, the consultative group system of research programs will embrace the major food crops and animals, and all of the econological zones, to be found in the developing world.[9]

INTERNATIONAL RICE RESEARCH INSTITUTE

The IRRI was founded in 1960 in the Philippines by the Ford and Rockefeller Foundations in cooperation with the Government of the Philippines. The operation of this center is now supported mainly by the Consultative Group on International Agricultural Research (CGIAR). In the past decade this center produced the miracle rice varieties and their related technology. It has also trained Asian scientists and technicians and has provided direct technical assistance to national R. & D. organizations in many of the rice-growing nations of tropical Asia.

INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE

The IITA is located in Ibadan, Nigeria and was established in 1967, also by the Ford and Rockefeller Foundations, in cooperation with the Nigerian government. The work of this institute concentrates on cowpeas and other legumes, root crops, corn, rice, and tropical cropping systems. This center serves the humid areas of Africa.

INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

The ICRISAT was established in Hyderabad, India in order to concentrate on the improvement of four crops especially important to farmers in low-rainfall areas—sorghum, millets, chick-peas and pigeon-peas. It was founded in mid-1972 by the World bank and the U.N. Development Program in cooperation with the government of India.

INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER

The acronym for this center is CIMMYT, as derived from its name in Spanish. The CIMMYT is located in Mexico and was established in 1966 by the Rockefeller Foundation and the Government of Mexico. The center was the source of the high-yielding dwarf wheats now in worldwide usage and has conducted significant work in corn development.

INTERNATIONAL CENTER FOR TROPICAL AGRICULTURE

This center is located near Cali, Colombia and also derives its acronym, CIAT, from its Spanish name. The Ford and Rockefeller Foun-

[9] World Bank, Annual Report 1975. Washington, D.C. p. 71.

dations, and the government of Colombia established CIAT in 1967 in order to speed the agricultural development of the humid tropics, especially in the Americas. The work of this center is concentrated mainly on improved beef production systems, and on improving the production of cassava, field beans and other important tropical crops.

INTERNATIONAL POTATO CENTER

This center, CIP, was organized initially by the Agency for International Development of the Department of State and the North Carolina State University in cooperation with the Government of Peru, where it is located. The main research efforts of CIP are aimed at intensification of the production of the white potato, a staple food of people in high elevations in the Andes and many other regions of the world.

INTERNATIONAL LIVESTOCK CENTER FOR AFRICA

ILCA was established in Ethiopia in 1974 by the Consultative Group on International Agricultural Research (CGIAR) in cooperation with the Ethiopian Government. Research at this center is concentrated on improvement of livestock production systems. An outreach program at ILCA allows research to be conducted in different regions of Africa under the auspices and sponsorship of the center.

INTERNATIONAL LABORATORY FOR RESEARCH ON ANIMAL DISEASES

This center, ILRAD, is located in Kenya and was also established by the Consultative Group on International Agricultural Research (CGIAR) in cooperation with the government of the host country. ILRAD concentrates its research activities on livestock, mainly the control of diseases. The central goal of ILRAD work is to improve the production of livestock.

WEST AFRICA RICE DEVELOPMENT ASSOCIATION

WARDA is located in Monrovia, Liberia, and was established by a consortium of West African nations, with partial funding from the Consultative Group on International Agricultural Research (CGIAR). This center is concerned mainly with the ecological conditions in West Africa as they affect rice production.

INTERNATIONAL PLANT GENETICS RESOURCES BOARD

The shortened name used for this organization is GENES. This is not a research center, in that it has no physical facilities. The Board consists of a grouping of scientists representing many nations. Their responsibility is to insure that the international research centers and national governments have the germ plasma collections that are necessary for their research activities. The home base for GENES is with the FAO headquarters in Rome, Italy.

CURRENT AGRICULTURAL RESEARCH INFORMATION SYSTEM

CARIS is administered by the Food and Agriculture Organization (FAO) with funding from the Consultative Group on International Agricultural Research (CGIAR) through 1976. After 1976, the FAO will integrate this computerized information gathering and centralization system into its own operations. CARIS is intended to be a central listing of all on-going agricultural research efforts, on a world-wide basis.

IV. GOALS AND PRIORITIES FOR FOOD-RELATED AGRICULTURAL RESEARCH

The National and Regional System

The policy-making system for setting national and regional research priorities has recently been revised. Assistant Secretary of Agriculture Robert Long testified that:

> In 1965, the Congress requested that the Secretary of Agriculture give immediate consideration to the establishment of an appropriate Research Review Committee comprised equally of representatives of the land-grant experiment stations, departmental research agencies, affected producer organizations, and appropriate industry representation to examine fully each and every line of agricultural research conducted by the Department and by the State experiment stations. This resulted in a report entitled "A National Program of Research for Agriculture," published in 1966. (I: p. 45)

Long went on to state that input from hundreds of scientists and administrators in the State Agricultural Experiment Stations (SAES), USDA, and private industry were used to compile this study. He noted that the report considered "the essential role of agriculture in our economy and the well-being of people at home and abroad. It evaluated the strengths and weaknesses in agricultural research and identified problems facing agriculture and forestry." (I: p. 45)

The development of a system for research planning and coordination at the national and regional levels evolved from a recommendation in that report. As Long noted, in 1971:

> . . . the Agricultural Research Policy Advisory Committee—successor to the Agricultural Research Planning Committee—adopted a regional and national agricultural research planning system. It began its implementation by arranging for the establishment of four regional research planning committees. In early 1974, the ARPAC membership was updated and a National Research Planning Committee (NPC) was established. (I: pp. 45–46)

The National and Regional Agricultural Research and Planning System attempts to coordinate the efforts of the research agencies and the extension service of the USDA with the activities of the SAES and the academic institutions represented by the National Association of State University and Land Grant Colleges (NASULGC). A memorandum of agreement between the NASULGC and the USDA sets out a "common objective" for their cooperative research efforts. These efforts are focused:

—To solve local, regional and national problems affecting agriculture, forestry, other renewable natural resources, and rural life.

—To provide scientific expertise to local, State, and Federal Government agencies, private organizations and individuals.

—To provide scientific competence for teaching and to make available increased research opportunities for graduate students.

—To provide scientific expertise and research in support of programs that relate to foreign nations. (I: p. 53)

The working organization for the planning, evaluation, coordination and support of these cooperative research efforts is the Agricultural Research Policy Advisory Committee (ARPAC)[1] which is administered jointly by the USDA and the NASULGC. A subcommittee of ARPAC, called the National Agricultural Research Planning Committee, was formed specifically to deal with the important planning element of ARPAC's activities. (I: p. 55) The policy statement of the National Planning Committee, submitted for the hearing record, explains the methodology to be used by that group in setting research priorities:

> Priorities for research will be formulated by utilizing the inputs of scientists, research program task forces, research program groups, regional planning committees and the National Planning Committee. Additional guidance on research priorities will be solicited from third parties and legislative bodies. Improved reallocation of research resources and the continued viability of the system will require that both decisionmakers and scientists react positively to the improved information and priorities thus obtained. (I: p. 73)

The ARPAC and the National Planning Committee set up Research Problems Areas for the research conducted by the publicly supported agricultural research system. The following list of goals for food-related Research Problem Areas was submitted for inclusion in this hearing record: (I: pp. 56–59)

—Insure a stable and productive agriculture for the future through wise management of natural resources
—Protect forests, crops and livestock from insects, diseases and other hazards
—Produce an adequate supply of farm and forest products at decreasing real production costs
—Expand the demand for farm and forest products by developing new and improved products and processes and enhancing product quality
—Improve efficiency in the marketing system
—Expand export markets and assist developing nations
—Protect consumer health and improve nutrition and well-being of the American people.

Two other Research Problem Area goals could be considered to have some elements partially related to food research:

—Assist rural Americans to improve their level of living
—Promote community improvement including development of beauty, recreation, environment, ecomonic opportunity, and public services.

Figure 1 illustrates that each of the four geographical regions of the United States (South, North Central, Northeast, and West) has a subunit under the National Planning Committee designated as the Research Planning Committee. Each Research Planning Committee subdivides again into Research Planning Groups to handle the coordination of research in a region for a particular Research Planning Area.

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[1] Members of ARPAC include individuals such as the administrators of ARS, CSRS, SRS, ERS, FCS, various representatives of other USDA units, and the representatives of NASULGC, SAES, and Colleges of 1890.

FACTORS/ORGANIZATIONS AFFECTING FOOD-RESEARCH POLICIES IN THE PUBLIC SYSTEM

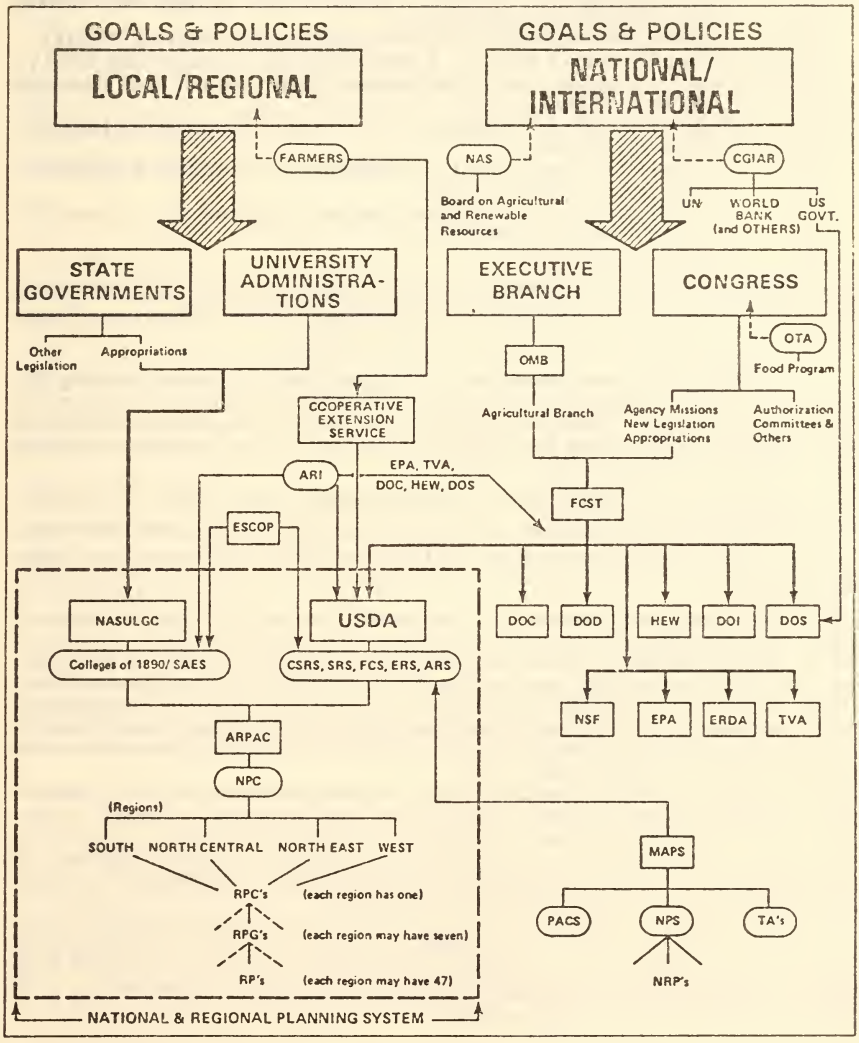

FIGURE 1.—*Factors/organizations affecting food-related research policies in the public system.*

This chart indicates all of the policy systems, factors, or organizations which could be identified during the hearings as affecting food-research policies in the public system. The National and Regional Agricultural Research Planning System is enclosed by dotted lines.

Abbreviations used in this chart are listed at the front of this report with the exception of the following:

NPC	National Planning Committee (Regional and National Agricultural Research Planning System)
NPS	National Program Staff (Agricultural Research Service, USDA)
NRP	National Research Program (Agricultural Research Service, USDA)
PACS	Program Analyses and Coordination Staff (Agricultural Research Service, USDA)
RP	Research Program (Regional and National Agricultural Research Planning System)
RPC	Research Planning Committee (Regional and National Agricultural Research Planning System)
RPG	Research Program Group (Regional and National Agricultural Research Planning System)
TA	Technology Assessment

In 1975, the ARPAC sponsored a national Working Conference on Research to Meet U.S. and World Food Needs. The objective of this conference as noted by Dr. Orville Bentley was:

> . . . to identify the most important problems requiring research during the next 10 to 15 years that affect the capacity of the United States to increase and improve domestic and world food supplies. The conference did not attempt to suggest research approaches for solving the problems or to recommend funding or organizational changes. (II: p. 157)

The ARPAC had attempted to include participants in the conference from all aspects of the public and private agricultural research sectors. Bentley presented the major findings of that conference and suggested that:

> The most important problems . . . represent the driving edge of research needs. They are the problems which should receive special consideration by research administrators, planners, and individual scientists. Many of the other problems identified as important at the conference also must be solved if the United States and world food needs are to be met. Nevertheless, the most important deserve at least first consideration in program formulation and cooperative planning. Some of them may serve as central needs around which other problems can be evaluated. (II: p. 171)
>
> These results will influence the direction of food research for many years to come. Careful targeting of effort on the areas and problems of greatest importance can contribute greatly to supplying consumers with ample food at reasonable prices and to alleviating the intermittent crises and chronic incidence of world hunger. They can help increase the stability and well-being of the U.S. agricultural industry. (II: p. 160)

In view of the importance placed on the results of this conference by ARPAC officials, it is assumed that future ARPAC policies and goals will be heavily influenced by the conference results, which will be summarized in its final report.[2]

U.S. Department of Agriculture

Many of the goals for national and regional agricultural research programs overlap those established by the USDA for its own agricultural research missions. The USDA submitted material for the record that included listing of "Food Research Goals." These included

[2] Draft copies of the first two chapters of the report of this conference were submitted for inclusion in the hearing record and appear in II: pp. 174–220.

the following: (1) resource conservation and use; (2) production and quality improvement; (3) protection of resource commodities and food; (4) human nutrition and food consumption; and (5) general technology and program evaluation. (II: pp. 1032–1036)

Each agency of the USDA, such as the Agricultural Research Service, (ARS) Farmer Cooperative Service, and so on, also has its own policy planning apparatus which meshes with USDA missions and the Agricultural Research Policy Advisory Committee/National Planning Committee above.

AGRICULTURAL RESEARCH SERVICE

T. W. Edminster, Administrator of the Agricultural Research Service, provided the Subcommittee with a listing of ARS missions and goals as follows (II: pp. 88–89):

USDA-ARS Mission	*Operating goal*
Agricultural production efficiency	New knowledge to increase productivity.
Agricultural marketing and distribution	Research for new products and processes for reducing marketing costs.
Agricultural exports	Develop commercial agricultural markets through research.
Rural development	Increase the supply of adequate housing (research).
Environmental improvement and resource development and use.	Land and water resource improvement to maintain and improve the quality of the environment and the natural resource base.
Consumer services and human resource development.	New knowledge to reduce health hazards.
Food and nutrition	Food and nutrition research.
Consumer services and human resource	New knowledge to reduce health hazards.
Foreign agricultural development	Research to help countries accelerate their agricultural development process.

The Agricultural Research Service, ARS, was in the process of developing and implementing a new planning and management system called MAPS (Management and Planning System) at the time of the hearings. Edminster testified that MAPS:

> . . . provides a framework for setting goals and objectives, allocating resources, providing technical leadership and optimizing opportunities and job satisfaction for our employees. (II: p. 77)

The ARS divides its research activities into National Research Programs each of which must contain the following elements:

> . . . a description of the current state of the art, visualized technologies needed in 10 years or less, research approaches that may prove successful, potential benefits and consequences of the new technologies, and levels of research efforts . . . (II: p. 78)

Edminster explained that for each National Research Program within the ARS:

> Priority formulation . . . begins with an examination of national priorities as reflected by economic conditions, public concerns, and the efforts of scientists and policymakers. Department and agency missions, goals and programs are reviewed annually and adjusted when necessary to meet changing conditions.

Information used in priority setting in the agency flows from a large number of valued sources, both within and outside the agency. The Congress, agribusinesses, producers, marketing firms, consumer groups, action agencies, and many others consistently request research information and recommend needs. We receive thousands of such communications from consumers or users of technologies each year.

Research scientists contribute to priorities when they recommend research proposals and plan their projects. Program managers and research leaders redirect projects and staff specialists recommend short and long-range redirections. In addition, the agency conducts numerous program and site reviews, workshops, indepth studies, annual reviews of specific project reports and plans. This is a continuous and dynamic process, the results of which are used in establishing specific priorities each year. . . . (II: pp. 79–80)

To establish the scope of the National Research Programs for each year, the ARS utilizes its National Program Staff, consisting of its four assistant administrators and the director of the International Programs Division. The National Program Staff is assisted by a technical advisory group, consisting of top ARS research scientists. Long had earlier informed the Subcommittees that a Program Analysis and Coordination Staff is also used by the ARS to:

Carry out scientific and economic analyses, technology assessments, do staff work on budgets, provide staff support to the Administrator and Associate Administrator, and work closely with the NPS in program planning and coordination. (I: p. 161)

The ARS had, at the time of the hearings, 67 National Research Programs and 8 Special Research Programs. The National Research Programs were grouped into the following major subject areas which give an indication of the research policies and priorities of the ARS:

Crop efficiency research; animal production efficiency research; research on housing; marketing efficiency research; research to expand agricultural exports; research to improve human health and safety; research on consumer services; food and nutrition research; research on conservation and use of land and water resources and maintaining environmental quality; and, research on watershed development. (II: pp. 93–97)

COOPERATIVE STATE RESEARCH SERVICE

The other USDA agency having a major influence on food-related research, the Cooperative State Research Service (CSRS), has control of policy and priorities only within its competitive grants program. Within this program, the CSRS selected seven areas of "national need" which were food-related in fiscal year 1976. In each area the CSRS provided further guidance as to the "specific areas of inquiry" which would be considered acceptable in proposals from participating institutions. (The seven selected subject areas have been listed in Appendix E of this report.) Although CSRS officials stated that they do consult with the ARS prior to selecting their areas of "national need," CSRS does have close control over these research priorities.

In terms of CSRS input into the policies and priorities of other USDA agencies and the State Agricultural Experiment Stations, Associate Administrator Dr. Thomas Ronningen testified:

CSRS' administrators and scientists participate in the regional-national research planning processes themselves at all levels and thus participate in priority setting and in formulating resource allocation recommendations.

CSRS scientists and administrators participate in interagency committees within the USDA and on a number of similar groups involving two or more

Federal departments. We provide information from the State research institutions and facilitate access to their expertise, which is considerable, for various national and Federal purposes.

The recent reorganization of the Agricultural Research Service has provided for improved interactions with CSRS and the State research institutions. These interactions have been encouraged and abetted by ARS administration. (II: p. 134)

State Agricultural Experiment Stations

The State Agricultural Experiment Stations (SAES) control a large portion of the agricultural research in progress today. Mention has already been made of the role played by the National Association of State Universities and Land Grant Colleges in terms of cooperation with the USDA on the Agricultural Research Policy Advisory Committee (ARPAC) program for the National and Regional Agricultural Research Planning System. Additionally, there is another organization, the Experiment Station Committee on Organization and Policy (ESCOP) which has as members the SAES directors and the Administrator of CSRS. Thus, for the Federal portion of the SAES funding, the policies of ARPAC/NPC and the ESCOP presumably have at least some influence on research goals. It cannot be denied, however, that since the formula grants made to the SAES and Colleges of 1890 are applied to programs mainly of local interest as determined by the experiment station directors, and since the State legislatures provide the majority of the funds for the SAES, the work of these institutions is guided almost exclusively by regional or localized priorities and policies. Dr. Thomas Ronningen of the CSRS noted that, although it had been somewhat difficult to achieve in the past, in more recent times the agreement between regional and national priorities was much better. (II: p. 136)

Some Goals and Priorities for Private Industry Efforts

A few of the witnesses, representing private research organizations outside the USDA system, elaborated on the research goals and priorities of their institutions.

The President of the Agricultural Research Institute, Dr. R. J. Aldrich, as a spokesman for many of the private sector firms engaged in food-related research efforts, stated that "there is concern that Government regulations directed at agriculture are requiring the industry . . . to reallocate research dollars from productive, to what might be called defensive research." (II: p. 230)

Aldrich felt that this was:

. . . in response to a growing number of government laws and regulations adopted to enhance environmental quality and assure human safety and which additionally seek to regulate fundamental agriculture activities, that is, the use of land, water, labor, equipment, chemicals, and plant varieties. These factors are cited to show that a higher and higher percentage of the U.S. agricultural research funds, the total dollars that are available, including those of industry, are being drained away from research designed to increase and improve the supply of agricultural products.

These demands on industry research budgets mean that more and more public funds are going to be required to provide the necessary basic and applied research data that we will need to produce and protect the food for this country and for export. (II: p. 231)

Another industry representative, Mr. Adolph Clausi, noted that respondents to a survey on future allocation of R. & D. dollars in the food industry had stipulated that large amounts would go into regulatory and legal efforts. He observed:

> At the top of everybody's list was a considerable increase in the dollars allocated for testing safety and toxicology, as well as for quality control and quality assurance. Product and process development, new or established, as well as basic sciences were much further down the list when it came to increase in funding. (II: p. 265)

Another question asked in that survey was:

> "What single problem will present the greatest challenge to food industry companies between 1975 and 1985?" The answer given most often was contraints resulting from government regulations. Next most frequently given answer was raw material costs or shortages and their consequent impact on food prices, but this was a very distant second. (II: p. 266)

Clausi testified that this change in priorities for private industry research efforts could have detrimental effects on future progress to meet world food needs. He said that private industry representatives, in their response to the questions in this survey:

> . . . indicated strongly that they are pessimistic about new developments forthcoming in food processing; that progress in the food industry's search for new ways to provide consumers with nutritious, adequate, and interesting foods is being slowed down significantly by the maze of regulations that must be followed—especially those which mean excess testing for safety and additional quality checks over those already in effect. This obvious preoccupation with safety, toxicology, and quality controls on the part of the food processing research community translates into less time and fewer dollars spent on basic research and new product development. Consequently, it also can mean that a gradual slowdown in the rate of technological progress in the food industry may well result. (II: p. 266)

Chairman Symington pursued this topic of "defensive research" in his questioning of Aldrich. He asked whether:

> . . . there has been an overemphasis on it, or whether the emphasis has been proper, but has tended to detract from the moneys that would have otherwise been available for productive research? Are you suggesting we simply need enough money for both, or that we should deemphasize the defensive [research] . . . ? (II: p. 253)

Aldrich replied that:

> . . . there are demands for the research dollar to do things that do not, in themselves, increase our production or the production capability of our livestock and of our crops. We are saying that as there are additional demands on the research dollar, these are cutting into the funds that are available in industry and in the universities. (I: p. 253)

William Hollis, science coordinator of the National Agricultural Chemicals Association, accompanied Aldrich and added that these areas of "defensive research" provide "an added dimension which is getting emphasis and deserves the emphasis. . . . We are having to divert from static, committed funds into these ancillary areas. All that we are saying is that these requirements are imposing new and sometimes inadequately conceived constraints on the existing agricultural research and production systems." (II: p. 254)

Consumer pressures for "natural" or environmentally safe foods were also stressed by Clausi as a force which changes industry priorities for research. In fact, he felt that such pressures could effectively lead to "antidevelopment" because of:

. . . some Americans' unrealistic attitudes toward our own country's food supply, attitudes which consistently thwart science and technology in their attempts to find useful solutions to world hunger problems. . . . I am talking about the back-to-nature advocates, who believe that foods right off the farm are the only ones fit to eat. Their feelings are understandable, but they conveniently seem to forget that in our highly developed urbanized society, very few of us live close enough to the land to do that. Rather, we must depend on an efficient food processing and distribution system to supply our needs. (II: p. 267)

National Policy Controls on Food-Related Agricultural Research

The various policy and priority setting mechanisms of the major public agencies performing and supporting agricultural research have been discussed in detail. Although mention was made of the "missions" of the USDA and other agencies which would determine the programmatic directions for those agencies, it seems clear that many other and diverse forces play a decisive role in the determination of actual research priorities. Concern about future world food shortages cannot be quantified, but may certainly be a factor in many research funding decisions. Local political pressures to bring economic viability to local farm industries may provide yet another source of policy control.

Many of these forces which were discussed in the hearings are capsulized here. Although all of the many hidden policy controls may not have been exposed during the hearings process, those which were mentioned are probably some of the most influential.

LIMITING OR GUIDING RESEARCH WITH THE FUNDING PROCESS

The greatest source of potential power in the control of agricultural research efforts is the limitation of funding by the Federal Government and/or the State governments, since a major portion of the food-related research is supported by the public sector. Projects will often be "tailored" to meet the national goal of the day—be it energy, space exploration, or aid to developing countries. Congressional declarations of policy in various areas are watched closely by both researchers and agency administrators so that budget requests will have a better chance of approval. At the same time, careful attention must be paid to the directives given by the Office of Management and Budget (OMB) in the Executive Office of the President. These may include directives to achieve certain budget levels or emphasize certain programs. Within the OMB, the Agricultural Branch has the responsibility to oversee the budget of the Department of Agriculture. The programs of other agencies which include food-related or agricultural-related research activities are coordinated within the OMB.

Other factors may affect the priorities placed on food-related research activities as well. Consumer concerns about the safety and nutrition of food may lead the regulatory and other agencies to emphasize these aspects of their research activities. Natural disasters which may ruin entire crops may also be influential in the decisionmaking processes for agricultural research within the Federal Government. Shortages of energy and/or other materials may precipitate a national

effort to pursue research for better methods to utilize these materials in the agricultural processes.

A few of the witnesses addressed the issue of funding controls and assessed the potential impact of such controls on the agricultural research system for the Nation. For example, Dr. Karl Mattil testified:

> If the United States is to maintain a leadership role in alleviating and eventually overcoming the world's hunger problem, its scientific and engineering leadership must be a major factor in reaching this end. Current Federal resources allocated to advancing food science and engineering are entirely inadequate for this objective . . . I could cite some almost unbelievable examples from my own personal experiences of projects that have a tremendous payout potential for which we simply have not been able to find a source of funds. (II: p. 322)

Dr. Glenn Pound testified that the National Science Foundation, which is responsible for much of the grant money currently provided for basic agricultural research, also uses the funding process to restrict research to certain areas:

> NSF must look at the needs that come before it and see that the U.S. Department of Agriculture, another Federal agency, has a substantial budget in R. & D. in agriculture, and therefore they tend to withhold support from really good research proposals as basic research that tends to be production oriented and commodity oriented. (II: p. 440)

Pound mentioned that, not only was the amount of funding available for competitive grants within the USDA inadequate, but that further limitations occurred since: "much of this is earmarked by Congress for commodity research." (II: p. 426)

SOCIAL GOALS AS LIMITS ON THE RESEARCH PROCESS

A number of socially oriented policies of the Federal Government were mentioned as factors which limit the type or amount of research performed in the food-related areas. Earlier in this report some mention was made of the regulatory influences on the allocation of research expertise and effort in the private sector. Mr. Adolph Clausi, a representative of the food industry, endorsed the idea, during his testimony, of assessing the effects of each proposed regulation on a "cost-benefit basis" and felt judgments as to the implementation of regulations which might affect the research process should be subject to a consideration of such priorities as safety, economics and so forth. Clausi stated:

> If it is clearly a matter of safety, economics should certainly take second seat. But if it is a matter of technical judgment or regulatory interpretation, then there ought to be provision for some judgment of latitude, especially if it is still a technical issue. (II: p. 291)

This point was as elaborated upon by Dr. Mattil who suggested that Federal regulations are often based on inadequate technical knowledge:

> In the area of nutrition and toxicology, our serious problem is that we are being asked to provide safe foods when scientists cannot define a safe food. . . . we need to go back to the drawing boards to define what is a safe food.
>
> . . . There is really very little knowledge about how much is safe and how much is unsafe. Yet, regulations are being established prescribing certain levels without adequate knowledge. In the area where we are interested in proteins, unbelievably there is presently no generally accepted method for evaluating the quality of the protein that you can get 75 percent of the nutritionists to agree on. We do not know when we create a new protein food whether we can get a majority of the

nutritionists to say it is good or it is bad. The only thing they agree on is that they do not have good guidelines. (II: p. 348)

Other areas such as energy conversion measures, waste treatment regulations and environmental controls on pesticide/fertilizer usage were also mentioned during the hearings as factors influencing the research process.

THE STATUS OF AGRICULTURAL SCIENCE AS A LIMIT TO RESEARCH ACTIVITIES

Some witnesses were concerned that the Federal Government, especially, does not accord agricultural research pursuits the same level of status as it does research efforts in other, possibly more "glamorous" areas and that this imposes constraints on agricultural research priorities.

Dr. S. Wittwer, Chairman of the Board on Agriculture and Renewable Resources of the National Academy of Sciences, testified that the "lack of scientific input into policies that affect agricultural productivity is becoming a National problem." (I: p. 7) As an example of the importance of the problem he noted that:

> The National Science Foundation was created and is currently supported by Congress, and reports directly to the President. Among the 21 options, or national problems, warranting greater research and development efforts according to [their] report . . . "Science Indicators, 1972," the 1973 National Science Board's report, food production is not on the list. There is also a complete absence of people even remotely connected with biology—let alone agriculture—in this top echelon of the National Science Foundation. (I: p. 8)

As a further example of this lack of status on the national level for agricultural sciences, Wittwer made the following statement:

> The Council on Environmental Quality was established in 1969. It annually reports directly to the President, who in turn transmits the reports to Congress. The annual reports have given little attention or priority to preferential uses and preservation of land for food production. The latest, or fifth, annual report is no exception. (I: p. 8)

At the time of writing of this report, the situation had been at least partially alleviated, since the National Academy of Sciences was requested to conduct a study of priorities in research and development for our Nation and for the rest of the world, in order to assure adequate food supplies.[3]

Additionally, the Federal Council on Science and Technology (FCST), which serves as the coordinating body for major research efforts involving more than one Federal agency, established a Food and Nutrition Research Committee in December of 1975. The proposed charter for that committee is bound into Appendix A of the hearings record. (II: pp. 1029–1030)[4]

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[3] Letters from President Ford, dated Dec. 3, 1974. See Appendix A for a summary of this study-request and an update on the progress.

[4] With the passage of the National Science and Technology Policy, Organization, and Priorities Act of 1976 (Public Law 94–282), the FCST is dissolved. It will be replaced by the Federal Coordinating Council on Science, Engineering and Technology. Although implementation of this act has not been accomplished as yet, it may be anticipated that many of the functions of the FCST will be taken up by the newly formed Council. It is not known whether the committee structure of the FCST, including the Food and Nutrition Research Committee, will be adopted by the new Council.

V. OTHER TOPICS CONCERNING THE MANAGEMENT OF AGRICULTURAL RESEARCH

Much of the additional testimony, on a variety of topics which could be classified as relating to the management of agricultural research, focused on the USDA. The remaining discussion deals with three separate topics: Program Reviews and Peer Review; Coordination of Research Efforts; and Transfer of Research Results.

Program Reviews and Peer Review

The Management and Planning System within the Agricultural Research Service (ARS) is also the source of program review activities. The national program staff has the major responsibility in this area, although it is assisted by the program analysis and coordination staff and approximately 250 technical/professional employees of the ARS in evaluating and planning the national research programs.

ARS Administrator T. W. Edminster felt that the planning and review system embodied in Management and Planning System was entirely adequate for the extensive research activities of the ARS. He stated:

> We have a strong base of top scientists, facilities and planning and analytical staffs that can be marshaled to cope with a wide range of agricultural problems. Equally important is the agency's central management, resource allocation and planning system which permits great flexibility in adjusting to changing needs and meeting new opportunities and urgencies in a highly participative environment. (II: p. 73)

The use of peer review or any similar rating system to judge the relative merits of various proposed research efforts within the ARS was not mentioned during the hearings. However, a three-tier internal review system does exist. This process is explained in the following excerpt from a recent report on the agricultural research system:

> The area director in each of the . . . geographic areas reviews the proposals that have been submitted to him. He may reject certain proposals at this time, based on his knowledge of national priorities or upon his assessment of the quality of the proposal. Most proposals, however, are sent on to the regional level where they may be evaluated in the light of a broader view of regional and national needs.
>
> At the regional office, the research proposals are rated by the Program Planning and Review Staff (PPR). This rating is based on such criteria as the assessed importance of the project in meeting national research goals, the urgency of the specific research subject, the probability of success in a reasonable time frame, the expected benefits of the project, and the probability of the same or similar research being conducted by other research institutions (SAES, private industry, and others.)
>
> After the proposals have been rated at the regional level, they are sent to the Program Analysis and Coordination Staff (PACS) in Washington, D.C. . . . Each project is rated by both an economist and a subject specialist in the relevant scientific discipline.

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A third rating procedure is conducted by subject specialists of the National Program Staff (NPS). PACS then prepares a list of all project proposals ranked according to their ratings and including a short description of the research, the number of scientist-man-years (SMYs) each project is expected to require, the proposed location of the project, and the estimated cost of project.[1]

The Cooperative State Research Service (CSRS) utilizes a system of internal peer review and ratings for its small program of competitive, or special grants. Another "special" review function within the CSRS is provided as a service to their "client" institutions, i.e., the State Agricultural Experiment Stations, Colleges of 1890, and Tuskegee Institute. CSRS Associate Administrator Ronningen described this system in his testimony before the Subcommittees:

A special review is activated only on the request by the Director of a client institution. They identify a research program or problem area that they want to improve. The scientists in that group and their leaders identify problems and opportunities and alternative ways improvement might be made based on their experience and knowledge.

CSRS helps to work out the review process and identify outside experts who can best react usefully to the resident group. The process culminates in an intensive review and discussion session over most or all of a week, followed by recommendations and reactions of the outsiders, first orally and then in writing. (II: pp. 134–135)

Coordination of Research Efforts

Discussions of the coordination of research efforts centered around two separate issues: implementation of coordination among various agencies/organizations which might be conducting similar, or in some cases, identical research programs; and, coordination of agricultural research efforts with nonagricultural research programs, the results of which could impact on the methods used for food production.

The Agricultural Research Service (ARS) provided the most information during the hearings on its efforts to coordinate research activities with others. T. W. Edminster of ARS testified that they "have strong cooperative working relations with other research agencies, State, industrial and Federal, which minimizes duplication of efforts and maximizes use and availability of special knowledge and special equipment." (II: p. 72) He also noted that "ARS has the opportunity to coordinate U.S. research and development needs and opportunities with those of foreign countries as part of its departmental Special Foreign Currency program for which the Agency is administratively and technically responsible." With respect to coordination efforts with the private industry research sector, Edminster stated:

Coordination with private industry research is on a comprehensive and a "problem by problem" basis. Publications of USDA research results provide industry with information to develop according to their needs. Individual USDA scientists discuss research problems with industry scientists individually and at formal meetings. The recent Kansas City, Mo., Working Conference on Research to Meet U.S. and World Food Needs was attended by over 150 delegates, representing many different user groups. Under the auspices of many scientific groups, farm and industry groups, and other private organizations, scientists from government, universities and industry are brought together for this kind interaction. (II: p. 71)

[1] Op. cit., Agricultural Research: Men, Money and Institutions. pp. 28–29.

In additional testimony on this topic, Dr. Richard J. Aldrich presented an example of coordination of efforts to produce the machinery necessary to institute a new farming technology. (II: p. 231) He said that such examples served to:

> . . . illustrate the important role played by the private industry in agricultural research in our country and how closely it is intertwined with that of the universities and the USDA in developing usable new technology. (II: p. 231)

During the hearings, Congressman Symington held a discussion with Robert Long, Assistant Secretary of the USDA, concerning the coordination of USDA efforts with those of other Federal agencies:

> One thing that I think is important is that both the ongoing efforts and the results of all these different research projects are cranked into the general knowledge of the Department officials as quickly as possible. . . .
>
> It seems to me that we would want very much to be assured that USDA and NSF, NIH, all of whom have been pretty much compartmentalized, as far as their vertical reporting obligations to their various chiefs are concerned, would have some . . . device for being sure that this information is disseminated and made useful as quickly as possible throughout the decision-making process . . .
>
> Is this done on some structured basis or do you just wait for articles to appear in the journals . . . ? (II: p. 660)

In response, Long stated that "quite a little bit of communication does take place regularly and normally within the scientific community on all subjects that have some mutual or common interests." (II: p. 660) He did say that there "could be, without doubt, some gaps here in terms of crossing the communication line," although such groups as the Federal Council on Science and Technology were relied upon to help in the coordination. Of the activities of the FCST, in this regard, Long testified:

> There is the Federal Council for Science and Technology which is used to assist in coordinating efforts of the Federal research agencies, and we do get together several times a year and talk about broader issues, and do surface a number of things which have a common relationship among us. And through that process we do have some communication, but I don't know if there is any formal mechanism. (II: p. 660)

In material submitted for the record, Long discussed the coordination of USDA with the regulatory agencies which might impact on agricultural processes:

> USDA researchers relate closely to staffs of a wide range of regulatory programs related to agriculture. In this way, their scientific know-how and research findings are considered in the development and implementation of regulatory programs. This includes USDA programs as well as those in other departments and agencies such as OSHA in the Department of Labor, the Food and Drug Administration in the Department of Health, Education, and Welfare, and the Environmental Protection Agency. (II: pp. 647–648)

The only other attempt which had been made to provide internal coordination of food-related research activities which was mentioned during the hearings was the use of the Current Research Information System, maintained by the Cooperative State Research Service (CSRS). Although most of the publicly supported research projects are reported into that system, it does not include the private sector research efforts. Both CSRS and Agricultural Research Institute representatives suggested that this was one of the basic problems with Current Research Information System and that solutions should be sought to this problem.

The interface and coordination of nonagricultural research efforts with the agricultural research community was also discussed in some detail. Considerable advances had been made in some areas, such as the application of remote sensing technologies to agricultural research and to farm production methodologies. A separate hearings session was held on this topic and much of the material from that session is summarized in Appendix B to this report.

Transfer of Research Results to Users

The USDA/SAES system is the only research performing organization in the food research system with an organization for the transfer of results to potential users. A complete description of that process, which the USDA calls the "research delivery system" appears in the record. (II: pp. 630–649) A brief summary of that system is presented here, along with a few comments made during the hearings concerning the transfer of research results from the USDA.

The important role played by the Agricultural Extension Service, and the success it has had as a part of the agricultural research system, was stressed by Chairman Thornton:

> It is clear that one of the basic strengths of American agriculture over the years has been the close ties between the American farmer and the American agricultural scientist. The indispensable link between them has been provided by the Agricultural Extension Service. (II: p. 894)

The research delivery system has three major components: (1) the Cooperative Extension Service; (2) the individual research and mission agencies of the USDA; and (3) the research scientists within the USDA. Of the role of the Cooperative Extension Service, the report stated:

> **The Cooperative Extension Service is a major component of the agricultural research delivery system since it is the vehicle for transfer of a broad spectrum of agricultural research findings to clientele in all counties and agricultural communities throughout the United States. It is a cooperative endeavor between the USDA Extension Service, the Nation's land grant universities and county governments.** (II: p. 635)

The link between individual farmers or other users of technical information and the researchers within the USDA, who develop that information, is clearly established through the use of the Cooperative Extension Service since it:

> . . . provides a mechanism through which findings and scientific know-how from the wide range of disciplinary fields of work in the USDA and land grant universities, applicable to agriculture and the general public, are made available to assist farmers, ranchers, and others to help solve specific problems and to build efficient systems of production, processing, and marketing for farm and forestry products. The Cooperative Extension System also provides a mechanism through which the USDA achieves its important goals relating to an adequate supply of food and fiber for the Nation's domestic and foreign markets. (II: pp. 637–638)

The cooperative program was funded in fiscal year 1975 by Federal, State, and county governments as follows: Federal, 44 percent; States, 39 percent; and counties, 17 percent.

The principal objective of the research delivery system, according to the USDA is to:

> . . . assure the utilization of research results and scientific know-how to help farmers and others engaged in agricultural pursuits, including forestry, to build highly efficient systems of production, processing, and marketing, for food and fiber products, with particular emphasis on needs and problems of the private, independent family-owned farm and owners of timberland. (II: p. 634)

Other members of the research community play an important role in the delivery system also, as the USDA points out:

Private industry serves importantly in the research delivery system through use of research results in providing supplies and services to farmers and others engaged in assembling, processing, transporting, wholesaling, and retailing food and fiber products. Private industry organizations and individuals serving as consultants make widespread use of training opportunities, information and recommendations provided by the public supported research delivery system. (II: p. 636)

The role of researchers within the USDA/State Agricultural Experiment Station system is integral to delivery of results since their findings are distributed to others in the research community through publications in professional journals, participation in conferences, meetings and seminars, and the teaching activities of many of these researchers in academic institutions.

The material in the record indicates that, while the primary user group of the Cooperative Extension Service is the Nation's commercial agricultural sector, it also serves part-time farmers and those with limited resources, and provides research results and other agricultural information to nonfarm people about home lawns, gardens and related subjects. (II: p. 640)

Mr. Othal Brand discussed how the research delivery system functions in terms of producers and distributors:

The new technology is developed at the State experiment stations and the U.S. Department of Agriculture and the Extension Service functions as a delivery system in getting the technology to the producers.

Now, we work with the stations in field trials and plant selections and seeking desired characteristics in the qualities in plants and also in advising them of what we really need in the industry for a particular purpose. (II: p. 483)

In general, the research delivery system of the USDA was highly praised during the hearings. Congressman Brown noted that:

. . . you very correctly point out that the agricultural research system has the best organization for delivering technology to the consumer of any part of the American system. I think that's correct. I think it's been demonstrated over 100 years . . . (II: p. 665)

VI. THE USDA RESPONSE TO EARLIER RECOMMENDATIONS

In 1969 Clifford Hardin, then Secretary of Agriculture, requested of the Division of Biology and Agriculture of the National Research Council "the establishment of an Advisory Committee that would represent the range of scientific disciplines involved in agricultural research. He suggested that the Committee review agricultural research as a science and advise the Department and the Land-Grant Universities on gaps in the scientific effort and on new advances that should be developed." [1] In 1972 the National Research Council issued the "Report of the Committee on Research Advisory to the U.S. Department of Agriculture," frequently referred to as the "Pound Report" after the Committee's chairman, Dr. Glenn S. Pound, Dean of the College of Agricultural and Life Sciences at the University of Wisconsin.

The Pound Report recommended sweeping changes in the organization and management of agricultural research within the USDA and was highly critical of certain aspects of the agricultural research system. At the same time many people within the agricultural research establishment were highly critical of the findings and recommendations of the Pound Report and challenged the objectivity and the quality of the report itself. Some of the statements in the report have been seriously criticized for making broad generalizations based on limited information, or for not being adequately documented with specific facts.

However, many of the witnesses testifying at these hearings suggested that the findings contained in the Pound Report were valid in 1972, and as of 1975 still had not been sufficiently addressed by the agricultural research establishment. The Subcommittees were interested, therefore, in obtaining a report from the USDA on the actions that had been taken in response to the Pound Report recommendations.

This report appears in I:pp. 99–123 of the record. The information furnished the Subcommittees came from several sources at the USDA and included:

1. Statement of N. D. Bayley, Director of Science and Education from 1968 to 1973, on the Report of the Committee on Research Advisory to the U.S. Department of Agriculture, 1972.
2. The Agricultural Research Policy Advisory Committee Review of the Committee on Research Advisory to the U.S. Department of Agriculture, October 13, 1972.

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[1] National Research Council-National Academy of Sciences. Report of the Committee on Research Advisory to the U.S. Department of Agriculture. Washington, National Academy of Sciences, 1972, 91 p. plus 464 p. appendices. p. 1. Cited hereafter as the Pound Report.

3. Agricultural Research Policy Advisory Committee Recommendations Relative to the Report of the Committee on Research Advisory to the USDA, February 20, 1973.

4. Response by Agricultural Research Service to the Recommendation in the Report of the Committee Research Advisory to the Department of Agriculture, National Research Council.

5. Actions of the Economic Research Service Following Release of the Pound Report, July, 1975.

6. Forest Service Input to USDA Response to Committee on Science and Technology Question No. 3 in Letter to Robert Long, Assistant Secretary, dated July 15, 1975.[2]

The Focus of the Pound Committee

The National Research Council-National Academy of Sciences Committee on Research Advisory to the U.S. Department of Agriculture focused its examination of the USDA-State Agricultural Experiment Station system on five separate questions:

1. Do the organization and management of research programs promote and encourage high quality research output?

2. Are the basic sciences adequately involved in research underpinning agriculture?

3. Are the agricultural sciences adequately integrated with their basic disciplines?

4. Is the quality of the scientific personnel engaged in agricultural research as high as it can and should be?

5. Does the research by agricultural scientists reflect the highest standards of the scientific community? [3]

The Pound Committee's findings with respect to these questions led to twenty recommendations. In general the report noted that bold moves were called for "in reshaping administrative philosophies and organizations, in establishing goals and missions, in training and management of research scientists, and in allocations of resources." [4]

USDA–SAES Management and Organization

The Pound Report made nine specific recommendations in response to the question of whether USDA organization and management was such that high quality research output would be encouraged.

These recommendations fall into three major categories:

—Greater participation by active researchers in deciding what research is to be done;

—A strengthening of the review system for administrators, the development of a mechanism for easy replacement of unsatisfactory administrators, and the screening of the scientific community at large when recruiting administrators;

—Examining the rationale for funding many small branch stations, the proportion of funding for State experiment stations as opposed to USDA in-house research; and communicating to Congress the harmful effects of excessive commodity (or other specified subject) earmarking of funds.

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[2] Note that responses of the Forest Service will not be included in the discussions of the remainder of this topic since this report is limited to food-related research.

[3] Pound Report, op. cit., p. 10.

[4] Pound Report, op. cit., p. 43.

THE USDA RESPONSE

The Economic Research Service (ERS) provided a short statement on actions that have taken place since the Pound Report. Two major management changes are identified. First, the Branch structure has been replaced "by a more flexible Program Area structure. Under so-called matrix management, temporary teams of economists and other researchers are organized under a project leader as required by the problem under consideration." Second, ERS is developing a process of "systematic identification and training of research leaders." (I: p. 121)

N. D. Bayley of the USDA also provided a general reply to the Pound Report, listing the following major changes in the Agricultural Research Service (ARS) that took place during the time of the Pound Committee's deliberations:

(1) Regulatory activities were separated from research by splitting ARS into two agencies; (2) management authorities were strengthened for program managers as compared to administrative managers; (3) the field structure of ARS was completely overhauled; and (4) the entire top staff of ARS was replaced or reassigned.

Also during the period of the Pound Committee's deliberations, the Federal-State regional cooperation and planning structures were restructured. The new organization provided for increased integration and coordination of USDA–SAES research efforts. (I: p. 101)

Input from researchers

Answering in more specific terms, the Agricultural Research Policy Advisory Committee (ARPAC) agreed with the Pound Report on the importance of participation of active researchers in the decision-making process and stated that the reorganization in the Agricultural Research Service (ARS) since the report has led to steps in this direction. The Agricultural Research Service's response also pointed to the reorganization. ARS also pointed out the important input of individual scientists and managers in the annual budget process and stated that though "The national administration and staffs provide guidelines . . . the research scientists and their managers identify and specify the actual research to be done." (I: p. 111)

Quality of administrators

Pound Report recommendations to improve the quality of administration suggested the strengthening of the review system for administrators. The Agricultural Research Service (ARS) stated that it was implementing an executive development program designed to identify specific managerial skills, knowledge, etc., needed to enhance the effectiveness of research administrators in their present positions and also to identify the resources through which these needs may be met. Additionally, this program is attempting to identify candidates with high potential for future assignment to managerial positions. (I: p. 112)

The Pound Committee also recommended the development of a mechanism for the easy replacement of unsatisfactory administrators: ARPAC thought "existing mechanisms to provide early identification of persons not suited to administration could be strengthened." (I: p. 103) ARS agreed that inefficient administrators must be removed, but because they are under the rules and regulations of the Civil Service

Commission, they "believe it appropriate to proceed with the replacement of any unsatisfactory research administrator through established procedures derived from laws." (I: p. 112)

ARPAC agreed with the desirability of screening the widest relevant population for administrative capability, but pointed out the importance of looking for management capabilities as well as scientific leadership in potential administrators. The Agricultural Research Service was not in complete agreement with this recommendation, stating that "because of CSC [Civil Service Commission] requirements and the fact that there are many highly qualified scientists on our rolls with demonstrated or potential managerial capabilities, we have not determined that it is in our best interests to 'screen and search' the scientific community at large each time an opening exists for a research administrator." (I: p. 113)

Efficient use of funds

ARPAC agreed with the "intended sense" of the Pound Report recommendation for a review of the rationale of branch stations but pointed out that "unproductive branch stations may be essential and have high productive potential if appropriately funded and properly managed." ARPAC believed that the recommendation calling for the close-out of many small field stations or the transfer of their responsibilities into the SAES wrongly implied that small locations per se were inefficient and unnecessary. The ARS response presented a list of locations (I: p. 113–114) that have been closed or have had their responsibilities transferred to larger research centers since 1969.

On the proportionate funding of State experiment stations as addressed by the Pound report, ARPAC thought a review board should work on a continuing basis to make recommendations on funding based on specific needs, and that the process "should not be reduced to a convenient formula or proportionality." (I: p. 105) ARS responded with a chart (I: p. 114) listing the appropriations for research for ARS and the Cooperative State Research Service from 1966 to 1975.

Finally, on the necessity of communicating to Congress the harmful effects of disproportionate commodity-earmarking of funds, ARPAC first questioned that there is a "disproportionate" amount of this; and secondly disagreed with the basic assumptions supporting this recommendation. To quote ARPAC's response:

> However, we take exception to the implication that commodity earmarking by the Congress is more likely to produce harmful resource allocation than would allocation by a consensus of scientists, decree by research administrators, or other alternative procedures by which resource allocations are made. (I: p. 106)

The Agricultural Research Service stated that each year its assessment of research priorities is presented to Congress. However, "there is no magic formula which can be applied to determine a ratio or percentage of effort to apply to research on the various agricultural commodities." (I: p. 116)

Basic Research in the USDA–SAES System

The next two questions in the Pound Report analysis were concerned with basic research: first, "are the basic sciences adequately involved in research underpinning agriculture"; and second, "are the agricultural sciences adequately integrated with their basic disciplines?"

The Pound Committee's major conclusions and recommendations on these subjects fall into three general areas:

—That there is inadequate support of basic research by the Department of Agriculture, and the USDA should "seek a greatly increased level of appropriations for a competitive grants program, which should include support of basic research in the sciences (biological, physical, social) that underpin the USDA mission." These appropriations should be free of commodity-earmarking and made available to scientists within and outside the USDA-State Agricultural Experiment Station (SAES) system;

—That the USDA and the SAES "provide greater support in their intramural programs to research in the basic disciplines related to their missions;"

—That there be greater integration at the working level between the agricultural scientists and the scientists in the basic disciplines.

THE USDA RESPONSE

Competitive grants

The USDA responses to the Pound Report generally disagreed with the idea of an expanded competitive grants system. The Agricultural Research Policy Advisory Committee (ARPAC) response stated, "we believe that major internal conflicts of interest would evolve within USDA in administering both in-house and competitive grants programs and that such conflicts would seriously impair the effectiveness of each." (I: p. 106) ARPAC recommended that USDA and State Agricultural Experiment Stations (SAES) concentrate on adequate Federal funding for their joint in-house research, which ARPAC believes is essential to ensure the continuity of funding necessary to the long-run success of the national agricultural research program. The Agricultural Research Service (ARS) pointed out that it does have a program of extramural research based on grants and contracts, but explained that their research is mission oriented and that any extramural research is designed only to be supportive and supplemental, based on its relevancy to the ARS mission. As a result many grants must be supportive of research aimed at particular commodities.

Intramural basic research

In response to the recommendation for greater support for the intramural programs of USDA–SAES in the basic disciplines, ARPAC stated that "there is now and has been substantial research in the basic disciplines in the total agricultural research program." (I: p. 110) ARPAC did point out the need to continually assess the balance between support of mission-oriented basic disciplinary research and problem-solving activity, and noted that this balance had been reviewed often in the past. ARPAC also stated that a great deal of basic research was done as part of projects which, if identified only by title, would not reveal the basic research component. The Agricultural Research Service also disagreed with the Pound Report stating, "Basic research is an integral part of all areas in which the Agency conducts research, but it is generally based on technological needs to meet practical objectives. For ARS to consider supporting research aside from these objectives would be contrary to good research management." (I: p. 117) ARS also pointed out that the Pound recommendation only calls for

"more" basic research, not specifying a percentage; and since "ARS will expend an estimated $87.9 million, or nearly 40 percent of its budget in FY 1975 on basic research, we are confident the report authors were not fully cognizant of ARS commitment to basic research." (I: p. 117)

Integration of applied and basic research

In response to the recommendation that there should be a greater integration at the working level between agricultural scientists and the scientists in the basic disciplines, ARPAC and ARS pointed to the recent reorganization of ARS as having as one of its basic objectives "the removal of the deterrents to formation of multidisciplinary teams." (I: p. 107) ARPAC also pointed out that the Economic Research Service is "moving away from research organized along disciplinary lines and toward integrated teams involving scientists in the basic disciplines." (I: p. 107) ARS went on to state "we feel the recommendation by the National Research Council—National Academy of Sciences Committee is fully met by current Agency policy." (I: p. 117)

Quality of Scientific Personnel

The fourth question addressed by the Pound Report was, "Is the quality of the scientific personnel engaged in agricultural research as high as it should be?" The Pound Committee saw the research atmosphere in which scientists work as one of the most important factors affecting the quality of research and made six recommendations in three areas to improve this factor in the United States Department of Agriculture-State Agricultural Experiment Station (SAES) system.

—Scientist evaluation: The report recommended that USDA strengthen its scientific personnel appointment and review system to include evaluation by the broadest scientific community. In addition, administrators should not serve as chairmen of personnel committees since they hold final approval authority. The report also recommended that SAES make broader use of peer judgment in evaluating scientific personnel with scientists from outside of the professor's department and college being included on the review committee. Again the recommendation added that department heads or chairmen should not serve on review committees.

—Scientist advancement: The committee recommended that the USDA provide increased opportunity for active researchers to advance as researchers to the highest salary classifications, believing that the present system forces scientists to become administrators in order to reach the top grades. The report also recommended that USDA search the scientific community at large when recruiting for research positions at all professional grades.

—Staff improvement: The report recommended "that funds to support an effective program for staff improvement in the USDA be set aside at or above the divisional level before allocations are made for project support." The Pound Committee believed that only in this way would support for the staff improvement program be "protected from the pressures of operational budget needs." The report also recommended that "SAES make a greater effort to provide study leave opportunities for their research staff and that both SAES and USDA

provide travel funds to enable staff to attend national and international meetings in their fields."

THE USDA RESPONSE

To these recommendations dealing with the quality of scientific personnel, the Agricultural Research Service (ARS) stated that, in their appointment "candidates selected from civil service registers are carefully screened and both formal and informal inquiries are made of the scientific community as to their qualifications . . ."

Scientist evaluation

On the review of working scientists the Agriculture Research Policy Advisory Committee (ARPAC) stated that evaluation by peers broadly representing the scientific community is desirable but went on to note that "since USDA like most Universities has a large and broad community of scientists there seems little need for including peers from outside the Department." (I: p. 107) On the same point ARS responded that although the review system does include a number of factors related to the individual's standing in the scientific community, "we are not in a position to include on a formal basis the views of the broader scientific community in our review system." (I: p. 117) ARS went on to explain that some changes had been made in the composition of peer group panels and committees as a result of the recent reorganization, but the basic evaluation system remained the same. ARS stated, "we do not agree with the NRC Report that the evaluation system has failed in many areas to develop top-quality bench scientists." (I: p. 118)

ARPAC and ARS both pointed out that administrators with final approval authority do not serve as chairmen on personnel review committees nor have they done so in the past. ARS further stated. "We have no intention of designating officials who have final approval authority as chairmen of our evaluation committees." (I: p. 118)

ARPAC responded to the Pound recommendation for improvements in SAES personnel evaluation by stating, "Most universities have definitive procedures which include peer evaluation in considering rank and tenure." (I: p. 107) However, ARPAC went on to say "More attention could well be paid to continual evaluation." (I: p. 107)

Scientist advancement

ARPAC did not agree with the Pound Report on the lack of advancement opportunities for qualified scientists in the case of biological and physical scientists but did believe that the same opportunities need to be extended "more fully to social scientists and engineers." (I: p. 107) The Agricultural Research Service was in complete disagreement with the Pound Committee on this point. Quoting the Pound Report contention that researchers are forced to become administrators in order to advance, ARS stated, "This is incorrect and our scientists are well aware that the present system provides for advancement based on their research achievements." As evidence of this ARS pointed out that as of "December 31, 1974 they had a total of 37 employees in super-grade and super-grade equivalent positions. Of this number 10 (or over 25 percent) were bench scientists."

Staff improvement

In terms of staff improvement programs ARPAC responded that, although the USDA is making a significant effort in this direction, it does lag in providing the equivalent of a sabbatical leave for professional improvement. ARPAC suggested consideration be given to establishing an item for training in yearly expenditure operating plans. ARPAC also agreed that opportunities for study leave was a matter that needed to be given more attention by SAES administrators. On providing more travel funds ARPAC stated, "In general, we believe USDA policies are adequate in this respect. State Agricultural Experiment Station (SAES) policies vary and some SAES administrators should work toward more liberal policies. Both USDA and SAES must give attention to means for implementing these policies." (I: p. 108)

The Agricultural Research Service, however, did not agree with these recommendations of the Pound Committee. They stated that "for years ARS has recognized the need for and value of an effective program for staff improvement," (I: p. 119) but they did not believe that a more effective program would result by setting aside funds before allocations are made for project support. ARS reasoned, "It is our opinion that the National Research Council/National Academy of Sciences recommendation would foster training requests not always related to need, on the premise that the expenditure is not being borne at the operative level." (I: p. 119) ARS thought a more effective approach to staff improvement would be "to regard the development process as an integral part of the research program." (I: p. 119)

In response to the recommendation for more study leave opportunities ARS pointed out that for a number of years they have urged the Department of Agriculture to seek the support of the Civil Service Commission for enactment of legislative authority to grant sabbaticals to scientists. However, such authority has not been given as yet.

Finally, ARS believed that it had a good record for numbers of scientists authorized to attend national and international meetings and stated that in FY 1974 more than 125 scientists attended international meetings and nearly 1200 scientists attended 16 national meetings of professional societies.

Planning and Project Review

The last question analyzed by the Pound Committee was, "Does the research by agricultural scientists reflect the highest standards of the scientific community?" The report stated, "Most of the specific disciplinary research studies made by the committee and its panels reveal a shocking amount of low quality research in agriculture." The report also pointed to evidence of "unnecessary duplication and poor selection of research projects." To remedy these problems the Pound Committee recommended that "USDA and State Agricultural Experiment Station (SAES) develop, cooperatively, a new project and program review system that requires peer judgments of the scientific quality of the projects and programs," and suggested consideration of the science panel review concept found in other Federal research agencies. The report recommended that panel members include scientists from pri-

vate universities, non-land-grant public universities, and industry as well as from USDA and SAES. In addition, new projects should be reviewed as early as possible and no later than one year after initiation. The report's final recommendation called for broad subject-matter program reviews at least every five years.

THE USDA RESPONSE

In its written response to the Pound recommendations the Agricultural Research Policy Advisory Committee (ARPAC) stated that although the recent reorganization will make some of the needed improvements in USDA mechanisms for project review and program analyses and evaluation, "we concur in the need for continued assessment, restructuring and improvement of these processes, both to make them more effective and efficient." (I: p. 111)

However, in the written and oral testimony of several USDA witnesses, the newly developed planning system, begun in 1972, was described as essentially fulfilling the recommendations of the Pound Report. The overall planning system of USDA-State Agricultural Experiment Stations (SAES), referred to as the Regional and National Research Planning System, was outlined. (Details of this planning system were presented in part IV.) During the hearings, Dr. Orville Bentley noted that this system does provide that "the research planning carried forth will be updated every 5 years and closely integrated with the identification of resource management needs and the planning of resource management activities." (I: pp. 51–52)

The new research planning system within the Agricultural Research Service (ARS MAPS) was also outlined during the hearings. (See also part IV.) In written testimony the Agricultural Research Service gave an example of how the new planning systems have worked utilizing peer review of projects as recommended by the Pound Report. ARS stated:

> During the first year after reorganization of ARS, the Northeastern Region conducted a peer review (five ARS scientists and three program managers appropriate for each line of work) of all current Work Reporting Units. On the basis of these reviews, plans were modified where improvements were indicated and resources were adjusted to provide better project support. Subsequent to this initial review, each new CRIS project submitted in the Northeastern Region has been reviewed by a panel of peers selected from the scientific community at large. These project proposals are revised in response to peer comments before they are approved and implemented. (I: p. 120)

ARS responded to the last recommendation of the Pound Report with a description of a newly implemented Agency-wide system of subject reviews and workshops. Twenty-six such reviews were held in FY 1974. ARS explained, "Many of these are broad in subject-matter coverage while some are relatively specific. Representatives from other Agencies and State Agricultural Research Stations also participate in many of these reviews. Policy has been developed to guide the Agency in planning, conducting, and implementing the recommendations resulting from the reviews and workshops." (I: p. 121) ARS believed this planning and review system fulfills the recommendations of the Pound report.

VII. EXAMINATION OF CURRENT PROBLEMS

Many of the witnesses who appeared at these hearings felt that the changing world framework of food needs and national goals would require far-reaching changes to the agricultural research system. Other witnesses, basically supportive of the existing system, also provided their views on aspects of the system which possibly could be improved. Many substantive recommendations were made, a number of which are discussed below.

Improved Policy Formulation, Management Structure and Coordination of Research

POLICIES

Many of the witnesses expressed the belief that, with the new demands on the agricultural research system, the goals and objectives of agricultural research need to be more clearly defined. Charles Romine, an economist with the Midwest Research Institute, summed up a number of the questions in this regard:

> I would also note that research priorities must take into consideration the national goals for agriculture. Some of the past criticism of agricultural research and its lack of direction or appropriateness can be attributed to confusion regarding policy issues. We believe the research community needs guidance on such critical policy issues as:
>
> 1. To what extent do we intend to encourage maximized efficiency in production of food and fiber?
> 2. What role are agricultural exports expected to play in maintaining a favorable balance of trade?
> 3. To what extent do we intend to use food as a diplomatic tool?
> 4. To what extent do we intend to protect the viability of the family farm, the rural sector, and the open market?
> 5. What tradeoffs are we willing to make between agricultural production and energy consumption, utilization of other resources that are in short supply, and environmental quality?
>
> We recognize that these are not separate issues, but are highly interrelated and that tradeoffs must be made which will result in the greatest overall benefit. The point is that there is no difficulty in obtaining agreement on the broad, general objective to conduct research which will improve the efficiency and productivity of U.S. agriculture.
>
> However, it will be difficult, if not impossible, to establish meaningful priorities for this research until we better define our national objectives for agriculture. I believe that with sufficient guidance on these critical issues, the agricultural research community will respond. (I: p. 460)

Several witnesses felt that the present agricultural research system is too "closed" in terms of its policymaking and priority-setting activities. Congressman Richmond, a Member of the House Agriculture Committee, made the very strong statement that:

> . . . USDA does its research in a vacuum. They seldom discuss research with any other Federal agencies. They spend money, many hundreds of millions of dollars on research, but unfortunately nobody from the outside world advises them or tells what the priorities really are in the United States. (II: p. 399)

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Dr. Perry Adkisson, an agricultural researcher, expressed a common frustration of scientists across the country who are themselves a part of this agricultural research community:

. . . our present system of establishing agricultural research policy, priorities, and allocation of funds leaves much to be desired. There is a great need for improving the system. Too often our best agricultural scientists, who may be located in the hinterland, but who also may have the best knowledge of the real problems of agriculture, generally have little or no voice in these matters. This is true in all the Federal agencies and institutions—USDA, NSF, EPA, HEW, and the National Academy of Sciences—that have influence on national agricultural research policies. There also appears to be little coordination among these agencies on problems of mutual concern. (II : p. 961)

A number of witnesses felt that the severity of some of these problems would be reduced if there were adequate representation of agricultural science at all levels of policymaking within the government. As Dr. Sylvan Wittwer expressed it:

Agriculture has not been in the top echelon, in our scientific priorities and thinking, in this Nation. I have referred to the composition of the National Science Board. The problem still exists. There is not agricultural scientific representation in the right places, in terms of research policy decisions. This needs to be corrected, and a focus directed at crucial issues, which I've tried to outline here this morning. Only then we can make progress. (I : p. 27)

Dr. Richard J. Aldrich expressed his view that:

. . . an agricultural scientist should be a member in full standing on the proposed Council of Advisors for Science and Technology. In addition there should be adequate representation of the food and agriculture industries on the other echelons of administration involved as well as on the survey bodies created.

The interrelationships among broad fields of science are increasingly apparent. . . . There must be an overview of this science in a setting which includes agricultural science as a full partner at the highest levels in our Federal Government. (II : p. 232)

MANAGEMENT AND COORDINATION

Dr. Sylvan Wittwer, director of the State Agricultural Experiment Station at Michigan State University and chairman of the Board on Agriculture and Renewable Resources of the National Academy of Sciences, discussed the need for management improvements. He emphasized that:

Any major new investment in agricultural research for food production and improved nutrition must be accompanied by changes in administrative procedures of involved agencies that will guarantee more efficient use of funds for recruiting the very best scientific talent that can focus on the biological processes that control agricultural productivity. (I : p. 21)

When asked whether increased funds would be effectively used by the USDA, which, according to the Pound Report, had perhaps become an unwieldy bureaucracy, Wittwer responded that:

There has been a reorganization. I'm not sure that reorganization itself is a solution. But there could be procedures developed, and an updating of criteria for research priorities established. An effective competitive element could be introduced. Program reviews need revitalization. Interagency relationships need fostering and cooperative exchange which does not now exist encouraged. There are not adequate interagency relationships between the agencies in dealing with top issues of food production and improved nutrition. (I : p. 27)

On the aspect of interagency coordination of agricultural research, Wittwer reminded the Subcommittees that, "Support of agricultural, food, and nutrition research is fragmented among 12 or more federal

agencies. There is not a single body which provides a focal point for technical guidance, coordination and facilitation of this immensely complex endeavor." (I: p. 148) He recommended the establishment of "a national overseeing, steering or coordinating body or commission." (I: p. 148)

Many of the witnesses were concerned with finding better means of coordinating agricultural research supported by the public sector, and several made suggestions similar to that of Wittwer. Dr. Edward Glass, professor of entomology at the New York State Agricultural Experiment Station, sounded a cautionary note, however:

> I would strongly recommend that all of our research and development not be dictated from Washington or California or any other one spot. (II: p. 582)

There also was general agreement that better coordination of public and private agricultural research efforts is desirable but may be a much more difficult problem. Very little seems to be known about the extent of industrial research, the kinds of research projects currently in progress, or even about the number or identity of the performers of that research.

Dr. Richard J. Aldrich made a suggestion for improving communication between the public and private sectors:

> Let me just speak briefly to the communication needs. I think much has been done to improve communication among agricultural scientists and managers in the public research sector, but there is room for continued and further improvement. The Current Research Information System, administered by the Cooperative State Research Service, has been an important element in this improved communication.
>
> Dr. Ronningen, in meeting with you yesterday, described this system in some detail, so I need not here. I would only mention that there is a missing component, in that we do not have the private industry research plugged into the system. There are good arguments for trying to plug it in. I am not necessarily saying I am optimistic we will get the job done, but the [Agricultural Research Institute (ARI)] has committed itself to try and come up with a way of plugging industry research into the information system so that it will be complete.
>
> We commend the chairmen of this joint committee for their expressed interest in improved science information exchange. We hope this can be translated into policies and incentives which, in the case of agriculture, will increase the use of CRIS and expand its data base. Further, we encourage you to work toward the development of some coordinated system for all of science. (II: p. 233)

Higher Quality Research

COMPETITIVE GRANTS

Almost all witnesses were in agreement on the need for additional funding for agricultural research, and many linked the amount of support available and the ways in which these funds are allocated to the quality of the research. As Dr. Richard J. Aldrich explained this relationship:

> The funding of research by the Federal Government should be done in a way which does not imply that there are first and second class scientists, with agricultural scientists falling in the latter category. I personally am inclined to think that some of our policies for administering dollars have, indeed, implied that agricultural scientists were not first class scientists. (II: p. 233)

Dr. William Hueg, deputy vice president of the Institute of Agriculture, Forestry and Home Economics at the University of Minne-

sota, believed that the overall funding situation for agricultural research is very serious:

We cannot continue to operate with appropriations for research adjusted only to the cost of living. The evidence is clear from the 39 reports of the task forces and the present planning effort that the research needs are real. If we are serious about increasing food production, not only for domestic but for the world, then I think we must begin to look at those reports and appropriate at the levels requested. (II: p. 594)

Witnesses disagreed, however, on the amount of additional funding which would be required to improve current research efforts substantially; nor did all agree on the proportion of funds which should be invested in formula grant versus competitive grant programs. The problem, as Dr. Edward H. Glass explained to the Subcommittees, is that:

Research programs cannot be turned on and off at will like water from a spigot. It takes time to build facilities and establish productive teams of scientists.

On the other hand, continuing unquestioned support can lead to complacency and lack of productiveness. (II: p. 566)

In terms of the type of funding made available, Hueg made some very specific suggestions:

My feeling is we ought to be really using the Hatch Act as a good, solid base for the Federal support of the programs at the State stations, and that that ought to maybe increase a little more than just the cost of living. But, attached to that, either through the Public Law 89–106 funds or very specific kinds of things that you think the stations and USDA have capacity to do, identify x millions of dollars for that purpose and put it out on a grant basis. (II: p. 621)

Dr. Glenn Pound, who had chaired the committee which developed the "Pound Report," brought to the Subcommittees' attention the 1972 recommendation "that the USDA seek a greatly improved level of appropriations for a competitive grants program for basic research in all the sciences that underpin the mission of the USDA and the SAES; that such funds be available to both Federal and non-Federal scientists; and that the funds be administered by a rigorous peer review system." (II: p. 426) Pound felt that, even now, there are still some "clear-cut weaknesses in the present grants and contracts program from the standpoint of meeting our basic research needs." (II: p. 426)

It was also suggested that, for some types of research, formula grants may not be the most effective means of support. New types of grant programs may need to be established to deal with new national goals in agricultural research. As William Hueg stated:

We may be coming to a time, though, when again, working together, we have to have more direction. Is it energy that we ought to be concentrating on, and if so, where should it be done? I don't happen to believe it ought to be done necessarily in every State experiment station.

There may be some places that have greater expertise in energy, and that could be accommodated through grants and contracts for specialized research. (II: p. 589)

Competitive grants were often considered to be the most effective way of funding certain types of research. This was also noted by Hueg:

I'm not convinced that all experiment stations ought to get into the most basic and fundamental research. They don't have the staff to do it. This would

mean that you'd use a lot of those resources to build new facilities, and let's use those new moneys to build on the people who already are strong, and what they need are additional hands to work with them. If you would put it in NSF, or NIH or wherever it might go—the only thing I ask is that the same opportunity be afforded to scientists in the State Stations and USDA to have access to those funds. Dean Pound's testimony spoke eloquently to that point—if you have people who are not affiliated with that system they do not understand it. (II: pp. 621–622)

Dr. Edward Glass made several specific suggestions along these lines for the improvement of research through a competitive grants program:

—That the "USDA–CSRS program of funding by grants—Public Law 89–106—should be increased. Such funding should be allocated . . . by program area rather than crops." (II: p. 567)

—That an "agricultural granting agency, comparable to NIH in the health field" might be established. (II: p. 566)

—That an "agricultural division" might be set up in the NSF to handle the granting of funds for basic and applied research in crop protection and other areas of agricultural research. (II: p. 566)

PROJECT AND PROGRAM REVIEWS

Witnesses were generally in favor of more extensive use of "scientific peers" in the review of research projects and programs. Dr. Pound made a strong statement on this subject:

The recent report of the National Academy of Sciences Committee studying agricultural research recommended that the USDA and SAES establish, cooperatively, a national system whereby research project proposals in agriculture would be subjected to rigorous review by scientist peers. Such a move would do much to upgrade the quality of science, directly in terms of the output of research itself and more subtly in the quality of recruits added to the field and to their scientific aspirations.

. . . It is admitted that both research systems have some mechanisms of peer review in operation now but it is felt that comprehensive and rigorous reviews are not common.

. . . In addition to peer review of project proposals, there is need for a related effort toward peer review of broad program areas. CSRS now offers comprehensive reviews to the SAES but does not have the resources to expand these to adequately meet the needs. If these could be expanded to cover more program areas, to have more balanced review teams, and to service USDA as well as SAES, significant upgrading of research planning and research management would result. (II: pp. 437, 438)

Dr. William Hueg took issue with the need for outside help in terms of peer review. Hueg testified:

Who are the peers, though? You see, I'm not going to take our program to somebody in a medical school and say, now, will you make a judgment on whether the content here is what it ought to be? Sure, look over our shoulder and see what we're doing, but I don't think they're in any better position to make the judgment than we are of, say, some medical research. And I think this is what you find in many of these review groups, that they are so far out of the activity of the real world that perhaps they miss what really needs to be done. (II: p. 622)

Isolation and Removal of Research Gaps

Witnesses listed numerous areas of research which they believe are currently underfunded in proportion to the possible benefits which would result from breakthroughs in these areas. Dr. Sylvan Wittwer

presented the most comprehensive list of research needs, emphasizing, however, that:

> Enhancement of productivity should still rank first in agricultural research priorities. But there are now other important indices. They include improving or maintaining nutritional quality. The quality of the environment should be maintained or improved. Resource input: land, water, energy, fertilizer, chemicals, equipment, their costs, their availability and renewability, must be considered. (I: p. 17)

In addition, Wittwer drew attention to what is, in his view, "one of the grossest of omissions in the agricultural research efforts of the Nation . . . photosynthetic carbon dioxide fixation . . . and biological nitrogen fixation." (I: p. 19) He further mentioned the need to: develop varieties and types of crops with less climatic, chemical, and genetic vulnerability; inventory the soil and water resources of earth and their crop producing potentials; increase efforts in weather modification research; collect climatic and weather information useful to agriculture, assess the magnitude and extent of the rapidly increasing acid precipitation and its effects on crops and soil; pursue new tissue culture techniques; and determine the nutritional qualities of various conventional and nonconventional foods.

Mr. L. C. "Clell" Carpenter of the Midcontinent Farmers' Association also listed a number of specific research efforts which need more emphasis in his view:

> I think we are going to be forced to develop some new pesticides that will be more compatible with the maintenance of the environment. . . .
>
> We have to have a better way to control animal waste runoff. Climatic science must have more advance in order to help farmers in planning and producing our food and fiber. Especially important is to determine your proper balance between reduced tillage and use of herbicides which will maximize energy saving, and that's one of our big problems, and it can be done. It is being done, and we need more help on that. (II: p. 869)

A listing of major areas of research deserving increased emphasis was also obtained from Dr. J. B. Kendrick, Jr., vice president of Agricultural Sciences for the University of California system. Kendrick included the very broad and ecologically significant field of plant protection (with particular concern for environmental quality); genetic and plant breeding research to increase resistance to diseases and pests, and to enhance salt tolerance and photosynthetic efficiency; land-use policy and conservation; the structure of taxation and other institutions that affect farm size; the structure and performance of the agricultural sector as a whole; and the role of international trade in agricultural commodities in regard to the broadly defined economic and international policies of the United States.

A substantial degree of consensus was reached among the witnesses on the need for increased research in many of these areas.

BASIC RESEARCH

Very few witnesses disagreed with Dr. Glenn Pound's observation that "There is also, in my judgment, a crying need for more basic research" (II: p. 413) in areas related to agriculture. Dr. Sterling Wortman of the Rockefeller Foundation referred to this type of "basic" research as "supporting" research because it is directed at a

specific goal and has a well-defined purpose. His view of the funds available for this type of basic research was that:

. . . the more fundamental but purposeful work on our major food, fiber and animal species—the supporting type—clearly has been neglected in this country during the years of surplus food production.

. . . In short, it appears that this entire area of highly important work has fallen through a very wide crack in our national research effort, to the detriment of both farmers and consumers. (II: pp. 16–17)

Although witnesses believed that more support in these areas is required, many emphasized that there is also a "need for a greater integration of applied and basic research efforts." (II: p. 412) Hueg mentioned this need, and also suggested that the role of the granting agencies in this process should be examined:

. . . we need to do a better job relating the basic and applied research programs to continued improvement of the food production and distribution system. We need to look more critically at the decisions made by the granting agencies. . . .

The standard response that we get too often in the State stations is that your funds are available through USDA and through State support, and therefore you do not need this. And I would contend that those funds are not sufficient as we delve into many of these unresolved basic issues of food production. (II: p. 595)

Several witnesses, including Pound, indicated that these problems are not caused by a lack of appreciation for basic research in agriculture. As an example, the Agricultural Research Service Administrator, T. W. Edminster, stated, "We are trying to increase our basic research in ARS and I know the experiment stations are attempting this, too. But we face one point of reality: Basic research is not the most attractive research in terms of seeing an immediate response. But we feel that this is one of the areas we must develop more thoroughly, because this is the basis for which we'll have food production 10, 15, 20 years from now—being able to support the basic research." (II: p. 127)

ENERGY AND THE ENVIRONMENT

The criticism was frequently made that, by focusing its efforts on increased production of commodities, the agricultural research system is not giving appropriate attention to the interrelationships of food, energy and the environment. Dr. Barry Commoner believes that this will mean serious problems in the future:

Research is designed to be a guide to the future and . . . the future of agriculture in this country is in doubt because the context in which agriculture is operating has begun to shift.

It has already been pointed out that the resources available for agriculture are now in short supply and the importance of research is to forewarn our production system about such changes.

Now, the main point . . . is that the present system of agricultural research . . . is not able to forewarn agriculture of impending developments. . . .

The reason for this shortcoming, is that . . . the existing system of agricultural research has concentrated on a narrow purpose—to produce food. (II: p. 504)

Commoner related this specifically to the serious concerns with the present and future availability of energy:

As matters now stand, agricultural production is heavily dependent on inputs of chemicals, pesticides, and fertilizers, and there is no doubt that any sharp

increase in the price of energy, or the price of chemicals will very seriously affect the cost of agricultural production.

That's as things stand now. I think that one of the consequences of the postwar changes in agricultural technology has been to generate precisely this vulnerability to the shortages of energy and other resources. I also think that this is a problem that we will want to solve, otherwise we will find that perhaps the most serious consequence of energy difficulties, which end up with rising prices, is that it affects the production and cost of food. (II: p. 552)

Dr. Sylvan Wittwer addressed the same problem:

I would say that there is inadequate consideration, for example, in research and development in the conservation of energy in our food system, and we ought to look at the total system. There is some funding now. There is support in this area, but I would say it is completely inadequate. (I: p. 25)

The complex and delicate relationships between agriculture and the environment are also part of this larger problem. Dr. William Hueg stated that:

We must also continue to study the relationship of food production practices to environment. The hysteria of the late 1960's and early 1970's led to the development of laws and regulations that reduce the opportunity for expanded production. Continued research in environmental relationships, both basic and applied, hopefully will ameliorate some of the regulations now in force. (II: p. 610)

Commoner made the following recommendation on this subject:

The answer, I believe, is to broaden the range of research organizations that are concerned with agricultural problems--and to include those which are particularly interested in the *connections* between agriculture and the larger environmental and production systems of which it is a part. (II: p. 523)

NUTRITION

Mrs. Esther Peterson, consumer adviser for a major retail food chain, delivered the most extensive testimony concerning the relationship between agricultural research and human nutrition. She noted that:

As things stand today . . . agricultural research has little to do with nutrition and human health. I am not saying that agricultural research and food production has nothing to do with food, nor am I denying that U.S. agriculture has provided the American people with far more food than they can consume, or that America is the breadbasket of the world.

Simply ask most agricultural researchers what their work has to do with nutrition, and they will answer with the same question, "What does agricultural research have to do with nutrition?" (II: p. 54)

She elaborated on this point, stating that it was her impression that:

Agricultural research has not been focused on nutrition because it has been focused on such things as productivity and on developing varieties of products which can be transported long distances or which mature into shapes and sizes that are more easily handled by harvesting or processing machinery . . .

Agricultural research should have been working on human nutrient requirements 50 years ago. It has not been a research priority; it is not a research priority now. I hope it will be. (II: p. 54)

"SMALL-SCALE" AGRICULTURE

Much of the agriculture conducted in the United States today can be described as large-scale, mechanized farming and it was frequently contended that the present agricultural research system supports and encourages this type of farming by its selection of research projects.

Much of the discussion of this issue had been generated by the USDA response to a recent General Accounting Office study of some problems impeding economic improvement of small farm operations.[5]

Charles Romine, who is associated with a non-profit research institute, agreed with the suggestion that the USDA is not doing all that it could in the research areas which would benefit the small, independent farmers:

I think that with all the touting of the support for the family farm that has gone on in this country . . . [USDA] has done very little to insure that the family farm would be preserved.

Our technological developments . . . such as large machines that are vastly expensive are extremely difficult for a small farmer to buy. No. 1, he often doesn't have the credit base to borrow the money, and often finds it difficult to make the payments.

I think what we need to do is decide whether we want to preserve the family farm. I mean, is there a good case for preserving it? Maybe there isn't.

But the one organization who probably should or could answer that question has not done so. (II: p. 471)

On an even smaller scale, Dr. Sylvan Wittwer thought that the "science of home food gardening" was "one area of technology that could be developed . . ." (I: p. 31) Wittwer thought the advantages to the fostering of home gardening had not been examined sufficiently by the USDA:

It also provides recreation. There is little fossil fuel energy input. High quality produce is available at the doorstep. You have no problems of packaging, transportation, and storage. Food is produced in your own backyard. There are segments of science that could be adapted from commercial production and applied to millions of home units. As one travels in Western Europe, one can see the science, perhaps the art, of home gardening much more advanced than in this Nation. We've paid very little attention to it. But now it's coming back. It's coming to the front. People have a renewed interest. The sale of garden seeds has risen to new heights. Almost everyone has an interest. I'm saying that here is where science could be put to use, perhaps in a rather unusual way, not only at home but also abroad. (II: pp. 31–32)

Several other witnesses also emphasized that such technologies do exist, but many of them are more highly developed in countries other than the U.S. Dr. Sterling Wortman provided the Subcommittees with the information that:

Much is being learned abroad about organization of systems to benefit small farmers and to promote rural prosperity—both on farms and in rural trade centers. Again, with a few exceptions, our scientists and institutions are not involved or even able to be abreast of such developments. They could be, of course, if given federal funds to allow certain of them to participate actively and on a continuing basis. (II: p. 46)

CLIMATE AND WEATHER

Dr. Sylvan Wittwer pointed out early in the hearings that "Climate and weather are the most determinant factors in food and other renewable resource productivity. The impact of changing climatic patterns and weather on food production is enormous." (I: p. 18) As the hearings progressed, the need for more research in these areas became

[5] U.S. General Accounting Office, Some Problems Impeding Economic Improvement of Small Farm Operations: What the Department of Agriculture Could Do, August 15, 1975, 31 p.

very apprent. For example, Dr. Wayne L. Decker of the University of Missouri stated:

. . . as the agricultural management system has become more sophisticated and complex, we have not removed the weather dependence of agriculture. . . . We have a complicated system that uses a lot of capital, utilizes all of our land, and this system is sensitive to the vagaries of the weather. (II: p. 829)

The potential benefits of this type of research for the American farmer and consumer would be very great, as can be especially made clear by the statement of Dr. Norton Strommen of the National Oceanic and Atmospheric Administration, Center for Climatic and Environmental Assessment:

There is no question in my mind that, if we had had the center for climatic and environmental assessment, we could have said a great deal about the Russian grain crop potential in 1972.

This year we were on top of it right from the start and the difference of this input is very evident, I think, just looking at what the outcome was in 1972 versus 1975.

The technology was there. There was no mechanism at that time to support getting this information in the form that it was needed and seeing that it got to the right places. (II: p. 879)

An extremely important part of the development of such systems is the support of advanced technologies such as satellite remote sensing and computer techniques. The dissemination of such information is a crucial aspect as explained by Dr. Decker:

It is my own contention that it is the advisory part of the system that we need to examine to promote a better exchange of information from the satellite remote sensing technique to the farmer. We need a specialized weather advisory system for agriculture. This specialized weather advisory system will provide assistance in some of the long-term decisions that the farm manager has to make, some of these decisions have 20- and 30-year payoffs. This system will also be involved in the day-to-day decisions of operating a farm. (II: p. 847)

GOVERNMENT REGULATIONS

Witnesses generally agreed that the increase in the number of government regulations which affect agriculture has markedly changed the research atmosphere in both the public and private sectors. These effects have been most pronounced in industrial research and development programs, however, as expressed most forcefully by the witnesses representing industry at the hearings.

Dr. Sylvan Wittwer pinpointed the source of many of these problems arising from Government regulations:

There is an unceasing demand for absolute safety. We can also now detect that which we cannot interpret. The lack of scientific input into decision-making that is increasingly controlled by lawyers and politicians is a national problem. (II: p. 300)

Mr. Adolph Clausi, for example, stated "that progress in the food industry's search for new ways to provide consumers with nutritious, adequate, and interesting foods is being slowed down significantly by the maze of regulations that must be followed." (II: p. 266) He unhesitatingly added, however, that industry does not really object to regulations *per se:*

There is a genuine need and desire to be as precise as we can about food safety, about nutrition, about wholesomeness, and about quality assurance. I think we

are at a very crucial time in our development. Many of the forces that were set in motion were very properly set in motion. But what we need to do now is to step back, not in an adversary situation, but in one of mutual understanding and respect and reach for truth, or at least closer to truth. . . .

We are for a workable system that will help assure the public's safety, while enabling the food processing industry to advance in all dimensions, not only just one. (II: p. 269)

To clarify this point, Clausi submitted a list of some regulations which he believes provide good examples of poorly conceived or poorly executed regulations, and made several recommendations regarding how, in his opinion, the major problems in this area could be alleviated. (II: pp. 285–289)

RESEARCH STRATEGIES

It was frequently contended that the agricultural research effort in the U.S. has been and continues to be strongly oriented to a "commodity strategy," and that such a strategy is not the most effective for meeting the demands to be placed on research in the future. The "systems" approach to agriculture which was advocated by several witnesses appeared to be incompatible with such a strongly "commodity oriented" strategy.

In material provided for the record, Robert Long stated that:

There are any number of alternative "strategies" that may be considered, especially when all the variations are added on. Some of the more commonly encountered strategies are discussed here, namely a defensive strategy, a commodity-oriented strategy, a geographical strategy, a functional-discipline strategy, a "moon mission" strategy, and a grants and/or protected funds strategy. (I: p. 179)

Upon examination of the various research strategies, Long remarked that:

It is our belief that in speaking of adopting a research strategy, we must speak of what is the relevant *mix* and not which *one* is the best. (I: p. 179)

Dr. Sterling Wortman also emphasized the need for a balanced mix of research strategies:

For a country of the size of the United States, a "commodity" approach, a "disciplinary" approach, and a "problem" approach to research, all are needed. . . .

Finally, there must be a multi-disciplinary approach to problems of each region, state, and locality in the United States—an aspect of our research effort which the recent reorganization of the USDA seeks, I understand, to strengthen. (II: p. 49)

Communication Among Researchers, Users of Research and Consumers

Closely related to the problems of filling research gaps is the problem of filling "communication gaps" among researchers within and outside the system of agricultural research, the users of that research and the consumers of the ultimate product of that research. In attempting to find solutions to the "world food problem," such communication must also cross international boundaries. Numerous witnesses addressed the various aspects of these important linkages.

COMMUNICATION WITHIN THE RESEARCH COMMUNITY

Many witnesses pointed out the need for interaction between those scientists within the agricultural research system and those outside that system—particularly those in the basic disciplines. According to Dr. Orville Bentley, dean of the College of Agriculture at the University of Illinois and co-chairman of the Agricultural Research Policy Advisory Committee:

> . . . communication between scientists within the USDA-State system and those outside of its is extensive, but it undoubtedly could be better.
>
> A large array of scientific societies, research workers conferences, technical seminars, and other public forums and the broad array of journals, reports, and all other sorts of treatises accompanying them, provide the framework for this communication. This often happens without regard to disciplines, organization or place of employment.
>
> When taken in total, agricultural scientists travel extensively, including cross-campus visits to another college or discipline group, for the purposes of broad scientific communication and learning. In addition to meetings, they visit the research facilities of non-agricultural scientists engaged in research of mutual interest. Visits by non-agricultural scientists to agricultural scientists probably exceed the traffic going the other way. (I : p. 198)

Several witnesses believed, however, that more could and should be done to encourage this communication. Dr. Sylvan Wittwer suggested ways that the Federal government might help:

> Fund, encourage, and support efforts (research proposals) that bring together scientists of the applied agricultural science disciplines with those of the basic research areas.
>
> In other words, fund proposals which have written in strategies to do this. The power of the budget to encourage such collaboration should be recognized. This will require inter-agency coordination as well as interdisciplinary collaboration in program development. (I : p. 143)

The commodity orientation of agricultural research funding was often mentioned as a reason behind inadequate communication among researchers; for example, Dr. Wayne LePori of Texas A & M University felt "that energy is an area that cuts across all commodities. When we have a commodity-oriented funding, then this is where interdisciplinary research can become a problem. We need to recognize this as an area where we need to make special efforts to have this interdisciplinary cooperation." (II : p. 1013)

To lessen these effects of commodity-oriented funding procedures, Wittwer suggested that federal agencies:

> Bring various disciplines together in a team effort on national problems.
>
> This could be encouraged by a collaborative granting procedure among federal agencies which recognizes and rewards an interdisciplinary approach for the applicants. (I : p. 146)

COMMUNICATION OUTSIDE THE RESEARCH COMMUNITY

Various aspects of the communication which takes place between researchers and those outside the research community fall under the rubric of "technology transfer." Although government agencies and numerous individuals are becoming more concerned with this general

problem, it does not appear that enough has yet been done in this area. Dr. David Barr of the University of Missouri stated:

I believe that technology transfer needs the moral support of Government. Technology transfer needs the stature that is associated with high technology research and development. (II: p. 727)

The Cooperative State Extension Service has performed a large part of this function for the USDA-State Agricultural Experiment Station system, and, in general, most witnesses agreed that it has been one of the great strengths of the U.S. agricultural research system. However, some believe that the effectiveness of the extension services has been diminishing. When questioned on this, Robert Long agreed that this was a cause for concern and could be attributed to the fact that:

. . . the extension leaders have a real problem today of trying to determine their audience. In all fairness to them they have a job to do greater than their resources, in terms of their human availability in the field.

The demands made on them, both from the urban community . . . as well as from the rural community, which has not lessened, has tended to dilute their capacity to do their job as effectively as they could at one time. (II: p. 686)

Communication in the opposite direction—that is, from the users of agricultural research and the consumers back to the research community—was also perceived by many witnesses to be inadequate. Dr. William Hueg felt that part of the trouble here:

Is that the consuming public have not been sufficiently conscious of the abundance which surrounds them or its source. Many people are two and more generations away from the farm and they have lost sight of how and where food and fiber comes from. Again, we in the experiment stations may be at fault for not telling this story adequately. The media have not been of great help, as they point out the scare stories and failures but seldom the successes. There are many more successes than failures in the agricultural research system. (II: p. 603)

Adolph Clausi believed that the situation is further complicated by:

Some Americans' unrealistic attitudes toward our own country's food supply, attitudes which consistently thwart science and technology in their attempts to find useful solutions to world hunger problems. (II: p. 267)

To help ameliorate such problems, Esther Peterson felt that:

It's very important to involve consumers in advisory committees on all levels, state, federal, industry, etc. It's necessary to allow consumers to provide significant input into agencies and industries and help establish policy. (II: p. 61)

In terms of the international aspects of technology transfer, Dr. Glenn Pound suggested that the U.S. Agency for International Development had not proceeded in an effective manner with its programs in the past for the transfer of food production technology to developing nations. He did concede that the problem is complex but stated that "there is no way that this country can avoid wearing the cloak of leadership in international agricultural development." (II: p. 445) He testified:

I can only say that we have picked our way along a rocky path to try to find the formulas for getting at this thing. We have met with only partial success

in my judgment. The most recent period of endeavors, which was a period in which there was strong emphasis on institutional building within these developing countries was certainly the right approach.

I think our Agency for International Development did not follow through adequately, in terms of trying to imbue these countries and these institutions with an adequate concept of what is research, effective research. I think we pulled out of the picture too quickly that way. (II : p. 446)

On the other hand, Clausi suggested that the real problem in getting technical expertise to these countries was with the attitudes of the governments of these nations:

U.S. agribusiness scientists are trying to transfer their technological expertise to underdeveloped nations—to help them make better use of available food materials; to improve their foods' nutritional content; to reduce spoilage and waste losses; and to achieve better processing, storage, and distribution methods. We have to realize we haven't really made very much progress.

The governments in most developing countries are not waiting with open arms for our suggestions on improving agricultural practices or modernizing their processing and distribution techniques. We still have a long, uphill education job before we will convince the people in most needy nations to accept and use U.S. know-how—especially when part of the problem we face overseas is a reflection of some attitudes we must deal with at home. (II : pp. 266–267)

Dr. Sylvan Wittwer addressed another aspect of the problem, the fact that foreign students are often trained improperly at U.S. academic institutions. He therefore suggested that:

We need to review our training programs for foreign graduate students, and for scientists abroad who come here. The exchange program has been a good one, but so often we train them to do the very kind of research that we do here with the sophisticated equipment we have which is readily available here but not abroad. What we teach them so often does not apply to the solution of the critical problems they have in their native lands. (I : pp. 35–35)

It was noted, however, that in certain cases U.S.-developed technology is applicable in other countries. Mr. Othal Brand, a grower from McAllen, Texas, explained that:

The agricultural technology developed in the Southern areas of the United States, such as in the subtropical areas of Texas, could easily be transferred to other countries in the subtropical and tropical areas of the world. I don't think that there is any question about that. (II : p. 486)

But Wittwer noted that, because the United States is located in the temperate zone, "there has been very little progress made . . . in the science and technology of food production in the tropics." (I : p. 35) He went on to state:

But when we realize the vast land and water resources that exist, in Africa and South America, the masses of people who live in the Tropics, and that so much of our technology is temperate zone agricultural science and technology, we've got a few problems in terms of translating what we know in terms of the needs of other nations. It's gradually being corrected; it's being understood; the problem is being recognized; and I'm sure this will change. But agricultural science is still new in the Tropics, in terms of the management of resources, in terms of pest management, in terms of crops and livestock that can be most efficiently produced. (I : p. 35)

APPENDIX A

Chronology of Major Events Affecting Food-Related Agricultural Research

APPENDIX A

A Chronology of Major Events Affecting Food-Related Agricultural Research

(1) The following chronology highlights the major events affecting the publicly supported agricultural research system. As with the hearings held by the Subcommittees, the emphasis has been placed on the food-related aspects of the subject.

(2) Note that this chronology does not provide comprehensive coverage of events affecting non-State Agricultural Experiment Station (SAES) universities, the private sector research system, or the international system. Due to the worldwide effects of food research, however, some of the more recent major events in the latter category have been included.

Date/year	Event	Summary
May 15, 1862	Agricultural Organic Act	Established the Department of Agriculture and assigned the Commissioner of Agriculture the task of acquiring and preserving "all information concerning agriculture which he can obtain by means of . . . practical experiments, by the collection of statistics, and by any other appropriate means within his power. . . ." The Department was elevated to Cabinet status in 1889. (12 Stat. 387, ch. 72)
July 2, 1862	Morril Act (or Land-grant College Act).	Authorized grants of land to the States and the sale of that land by the States for the establishment of agricultural and mechanical colleges. The Act meant the first establishment of formal mechanisms for cooperative Federal and State government participation in financing academic activities related to science and research interests. (12 Stat. 503)
Mar. 2, 1887	Hatch Act	Established the agricultural experiment stations to operate in conjunction with the land-grant colleges. First Federal legislation aimed directly at promoting agricultural research on a nationwide basis. As amended in 1955, the Act is the primary source of authorization for the States to conduct agricultural research in connection with, and supported by the Federal Government. There is a fund matching requirement, (24 Stat. 440)
Aug. 30, 1890	Organic Act of 1890	Provided for a portion of the funds coming from the sale of public lands to go towards the "more complete endowment and maintenance of colleges for . . . agriculture and . . . mechanic arts now established, or which may herein after be established, [funds] to be applied only to instruction. . . ." (7 U.S.C. 450i)
Mar. 16, 1906	Adams Act	Strengthened both financial support for agricultural experiment stations and their control by the Federal Government by increasing annual funding but restricting use of funds to "conducting original research or experiments bearing directly on the agricultural industry of the United States." Also, SAES now were required to obtain prior approval of their expenditures of Federal funds, whereas before the Act they had reported to the Secretary on their activities after programs had already been funded. (Public Law 47; 34 Stat. 63)
May 8, 1914	Smith-Lever Act	Provided for cooperative agricultural extension work between the agricultural colleges receiving benefits under the Morril Act of 1862. The Act also authorized extension work consisting of "instruction and practical demonstration in agriculture and home economics" for people not in the colleges. By this Act then, the Extension Service of the Department of Agriculture was formerly established providing a link between government research and the local farmer. Funds appropriated by the Federal Government to the extension program were required to be matched by State and local funds. (Public Law 95; 38 Stat. 372)
Feb. 24, 1925	Purnell Act	Authorized additional funds to be appropriated for each agricultural experiment station for fiscal year 1926 and thereafter according to a graduated scale. Funds were to be used for investigations relating to agricultural products including research into the "establishment and maintenance of a permanent and efficient agricultural industry." (Public Law 458; 43 Stat. 970)

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Date/year	Event	Summary
June 29, 1935	Bankhead-Jones Act	Provided for the expansion of scientific, technical, economic and other research into the laws and principles underlying basic problems in agriculture. USDA implementation of the Act led to the establishment of regional laboratories located according to problems of that area. (Public Law 182; 49 Stat. 436).
1946	Research and Marketing Act of 1946.	Further expanded and defined the purposes of Federal support for research, the areas of research to be pursued, and where appropriated money was to be allocated. Specifically, the objectives of the Act were to provide for research into basic laws and principles relating to agriculture; to promote the efficient production and utilization of products of the soil and a sound and prosperous agriculture and rural life; and to assure agriculture a position in research equal to that of industry. The Act also established a national advisory committee composed of 11 members, 6 of whom were to represent producers, or their organizations. The purpose of the committee was to encourage cooperation between officials of the Department of Agriculture and producers, farm organizations, and industry groups in the development of research programs to meet the objectives of the Act.
Nov. 2, 1953	Agricultural Research Service established. Reorganization Plan No. 2 (and other authorities).	This plan allowed for formal establishment of the Agricultural Research Service (ARS) within the U.S. Department of Agriculture. ARS carries on basic, applied, and developmental research in the areas of livestock; crops; pest control; soil, water, and air resources; domestic and export marketing; use of agricultural products; food and nutrition; consumer services; rural and international development; and agriculturally related health hazards, including food safety.
1953	Farmer Cooperative Service established.	The FCS was formally established as a separate agency within the U.S. Department of Agriculture at this time. Original authority for work done by FCS was given by the Cooperative Marketing Act of 1926.. Its fundamental purpose is to help farmers help themselves through the use of cooperative organizations. The agency provides technical assistance and research to improve cooperative performance. Studies concentrate on financial, organizational, legal, social, and economic aspects of cooperative activity in U.S. agriculture.
Apr. 3, 1961	Economic Research Service established. Secretary's Memorandum No. 1446, Supplement No. 1 (under Reorganization Plan No. 2 of 1953, and other authorities).	This memorandum formally established the Economic Research Service (ERS) within the U.S. Department of Agriculture. ERS is responsible for the development and implementation of a program of economic research designed to provide economic information for the USDA, other Federal decisionmakers, farmers and related industries, and the general public. Research findings are made available through research reports on major commodities and the national and international economy.
July 19, 1961	Cooperative State Research Service established.	Under the authority of Reorganization Plan No. 2 of 1953, the Secretary of the USDA established the Cooperative State Research Service (CSRS) to administer funds for State agricultural and forestry research authorized by the following acts: The Hatch Act of 1887 as amended; the McIntire-Stennis Act of 1962; the Act of Aug. 4, 1965; and the Rural Development Act of 1972. CSRS reviews and approves in advance each research project proposed to be funded in whole or in part by these Federal funds and reviews and evaluates the State institutions' research programs and expenditures administered under the acts. CSRS also assists in the coordination of research programs between the States and USDA.
1961	Statistical Reporting Service, renamed.	The Bureau of Estimates, first established in 1903, was changed to the Statistical Reporting Service (SRS) under authority of Reorganization Plan No. 2. SRS prepares estimates and reports of production, supply, price and other items necessary to the operation of the U.S. agricultural economy. The Service also reviews USDA plans and questionnaires related to the collection of statistical data for use in research, regulatory, and other Department programs.
1964	Agricultural Research Planning Committee (later ARPAC), established.	This committee was formed by a joint agreement of and with representation from the U.S. Department of Agriculture and State agricultural research organizations. The committee was later renamed the Agricultural Research Policy Advisory Committee (ARPAC). In a joint memorandum dated Jan. 11, 1974, from the Secretary of Agriculture and the President of the National Association of State Universities and Land-Grant Colleges (NASULGC), the objectives of the committee were outlined as follows: (a) to develop recommendations for policy with respect to planning, evaluating, coordinating and supporting long-range agricultural research programs and determining the appropriate areas of responsibility of Federal and State agencies in carrying out these programs; and (b) to develop further the bases for cooperation in planning and implementing national, regional and interstate research programs.

Date/year	Event	Summary
Aug. 4, 1965.....	Public Law 89-106 (or the Special Research Grants Act).	This Act authorized the Secretary to make grants to State agricultural experiment stations, colleges, universities, and other research institutions and organizations and to other Federal and private organizations and individuals for basic and applied research to further the programs of the Department of Agriculture. A large part of the funds appropriated under this Act in recent years have gone to the land-grant colleges of 1890 and Tuskegee Institute. (79 Stat. 431)
1966.....	Current Research Information System (CRIS) established.	CRIS is an automated research information system administered by the CSRS of the USDA, CRIS contains projects for all research conducted by the publicly supported agricultural research system. CRIS provides information for interchange among individual scientists as well as for the planning, coordination, and mangement of national and regional agricultural research programs. The information is updated annually.
1971.....	Consultative Group on International Agricultural Research, (CGIAR) formed.	CGIAR is cosponsored by the World Bank, the Food and Agriculture Organization of the United Nations, and the United Nations Development program. CGIAR is a consortium of internatioanl banks, assistance agencies, governments, and private foundations which provide financial support to a group of international agricultural research and training centers. The major objective of the Consultative Group is to assist the developing nations to rapidly increase output of basic food crops, both to meet the food needs of growing populations and to speed the economic development that is needed for an improved rural and urban standard of living.
Aug. 30, 1972.....	Rural Development Act of 1972..	This Act authorized the Secretary of Agriculture to conduct, in cooperation and in coordination with colleges and universities, research and basic feasibility studies in any field or discipline which may develop principles, scientific and technical knowledge, new technology, and other information to achieve increased rural development. It also authorized research and development programs in management, agricultural production techniques, new products, cooperative marketing, and distribution suitable to the economic development of small-farm operations. (86 Stat. 671)
1972.....	Report of the Committee on Research Advisory to the U.S. Department of Agriculture (Pound Report) Published.	The Committee was established by the National Research Council in 1969, at the request of the Secretary of the Department of Agriculture. The Secretary asked that "the committee review agricultural research as a science and advise the Department and the land-grant universities on gaps in the scientific effort and on advances that should be developed." The summary of the 1972 report stated that although the committee found many research programs in USDA and SAES of high quality their findings generally indicated that "much agricultural research is outmoded, pedestrian, and inefficient. . . ." The committee made 20 recommendations for changes in administrative organization, the establishment of goals and mission, the training and management of research scientists and the allocation of resources within the USDA-SAES system to correct the inadequacies they found.
1972.....	Regional and National Research Planning System implemented by ARPAC.	This is a planning system jointly sponsored by the U.S. Department of Agriculture and the National Association of State Universities and Land-grant Colleges to facilitate the coordinated development of research programs at all levels—local, regional, and national—with inputs from Federal, State, and industry research organizations. Specific objectives of the system include: more effective use of available scientific talent, laboratories, and other resources in working toward the solution of agricultural and forestry problems; identifying emerging problems of national and regional significance and directing resources to the solution of high priority problems; and increasing the integration of efforts among participants in the system. The basic structure of the system consists of 4 regional planning committees and a National Planning Committee (NPC). The NPC, established in 1974, establishes guidelines for national and regional planning operations, monitors performance, reviews inputs from the regions, and evolves a national plan for each cycle of the operation.
November 1974...	World Food Conference in Rome..	Convened under the aegis of the United Nations as a result of increasing reports of food scarcities, the conference addressed the questions of international food relief, international food reserves, and increased food production in chronically food-short areas. Conference participants failed to reach agreement in several critical areas including the provision of immediate food relief, the funding of agricultural development and the establishment of food reserves, but did produce a "Programme of Action" which set forth some long-range goals for agriculture. In the area of development Conference recommendations included a call for developed countries to provide increased financial and technical assistance to developing countries; the provision of adequate supples of pesticides as well as research and training in their use; and increased attention to high-quality seed supply and development. The Conference also recommended the establishment of an International Fund for Agricultural Development to finance development projects in the developing countries. Provision was also made for the establishment of the World Food Council. The Council was "to serve as a coordinating mechanism to provide over-all, integrated and continuing attention for successful coordination and follow-up of policies concerning food production, nutrition, food security, food trade and food aid . . . by all agencies of the United Nations system. . . .'

Date/year	Event	Summary
Dec. 3, 1974	World Food Study requested of NAS.	President Ford addressed a letter to the National Academy of Sciences requesting their aid in "a major effort to lessen the grim prospect that future generations of peoples around the world will be confronted with chronic shortages of food and with the debilitating effects of malnutrition." The President requested that NAS develop "specific recommendations on how our research and development capabilities can best be applied to meeting this major challenge." In November 1975, the Academy sent an interim report on the progress of their work to the President, along with a report by the NAS Board on Agriculture and Renewable Resources titled "Enhancement of Food Production for the United States." The focus of the later study was on the improvement of U.S. food producing capabilities. The report pointed to "some gross deficiencies in our current investments in agricultural and food research" and gave recommendations for "replenishing the scientific pool of knowledge that has been drawn upon heavily during the last 2 decades without being adequately maintained." The interim report itself looked at food problems from a global view and discussed the areas of research, wherever conducted, which if successful could enhance food production in the developing countries themselves. The study emphasized the need for greatly expanded participation by U.S. agricultural researchers in international research activities. The final findings and recommendations of the NAS committee are to be published in June 1977.
June 25–26; Sept. 23–25, 30; Oct. 1–2, 24–25, 1975	Agricultural Research and Development hearings held.	These hearings on Agricultural Research and Development, the subject of this report, were held before the Subcommittee on Science, Research and Technology and the Subcommittee on Domestic and International Scientific Planning and Analysis of the Committee on Science and Technology.
July 9–11, 1975	Working Conference on Research to Meet U.S. and World Food Needs held.	Sponsored by ARPAC, the objective of the conference was to identify the most important problems requiring research during the next 10 or 15 years that affect the capacity of the United States to increase and improve domestic and world food supplies. No attempt was made to recommend research approaches or organizational changes to solve the problems identified. Delegates represented producers and processors of agricultural products, marketing firms, national farm organizations, farm labor groups, consumer, environmental and conservation groups, nutrition specialists, and Government agencies. ARPAC also established 2 committees to develop follow-up plans for the conference. These committees were to insure that the publicly supported research system was informed of the results of the conference and that the results were used in determining future research programs. They also were to establish an acceptable data base regarding ongoing research as related to the priorities that resulted from the conference.
c.1975	The Current Agricultural Research Information System (CARIS) established.	Administered by the FAO of the United Nations, this automated information system keeps track of all ongoing international agricultural research projects. The base of operations for the CARIS system is at FAO, Rome, Italy.
Dec. 9, 1975	Committee on Food and Nutrition Research established within the Federal Council for Science and Technology.	The purpose of the committee as stated in its charter is "to promote planning and coordination of food research in the Federal Government and between Federal agencies and other public and private research organizations. Specific functions of the committee include: collecting, compiling, and disseminating information on the Nation's food research and food research delivery system programs; developing and updating plans for Federal aspects of comprehensive U.S. food research programs to meet future domestic and international needs for food; and preparing reports describing the activities, findings and recommendations of the committee.
Feb. 5, 1976	H.R. 11743, National Agricultural Research Policy Act of 1976, introduced.	The purpose of this bill, introduced by Congressman William C. Wampler is "to emphasize agricultural research as a distinct mission of the U.S. Department of Agriculture; to be certain that all agricultural research is effectively coordinated; and to provide a mechanism for identifying the Nation's highest priority problems for agricultural research." The proposed mechanism is; the National Agricultural Research Policy Committee to be established as a permanent committee within USDA. The bill was referred to the House Agriculture Committee and hearings were held in February. The bill was reported out of committee in May. Debate in the House was scheduled to begin at the time of this writing.
May 11, 1976	National Science and Technology Policy, Organization and Priorities Act of 1976.	Outlined principles of a science and technology policy for the United States and provided for science advice to the President through establishment of the Office of Science and Technology Policy within the Executive Office of the President. The Act also established the Federal Coordinating Council for Science Engineering, and Technology to coordinate and recommend policies on science activities affecting more than one Federal agency. (Public Law 94–282.)

APPENDIX B

Examples of Some On-Going Agricultural Research Projects

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Examples of Some On-Going Agricultural Research Projects

The following is a summary of ongoing agricultural reseach projects discussed during the hearings. It is important to note that it was not the intention of the Subcommittees to determine all the programs currently being carried on in agricultural research and development. However, a number of witnesses during the field hearings and in Washington did discuss projects with which they were involved. That information has been brought together in this section to provide some specific examples of the current topics of interest in agricultural research. (See table I for more specific data on research projects in FY 1976.)

CROP IMPROVEMENT RESEARCH

Dr. Frederick R. Miller and **Dr. Lloyd W. Rooney** of the Texas Agricultural Experiment Station (TAES) discussed the agricultural crop improvement research for increased food production underway at the station. Specifically, they described their work in sorghum research and singled out their sorghum conversion project as "the cornerstone to our current improvement programs." Miller stated, "this joint TAES–USDA project changes tall, late or nonflowering sorghums from the tropics into short, early forms which can be used in the temperate zones of the world. This is done by substituting up to eight genes which control height and maturity to obtain the desired genotypes." Rooney went on to describe another phase of the program in the area of sorghum utilization research. He explained that work "ranges from basic research on kernel structure and composition to development of new methods to process the grain which require less energy to studies of how to harvest, process, and feed all portions of the sorghum plant." Rooney noted that in cooperation with these projects "work is also underway to develop new sorghums with built-in improvements in end-use quality." (II: pp. 974; 988)

Dr. James Martin discussed some of the recent accomplishments of crop improvement research work at the Arkansas Agricultural Experiment Station. These included: development of disease resistant soybeans, new rice strains, an early maturing wheat variety, and bramble fruits and strawberries capable of mechanical harvesting. (II: pp. 897, 898)

Some of the research underway at the Arkansas Rice Experiment Station was described by **Mr. Francis J. Williams** who pointed out that each year they work with 20,000 different strains of rice in their variety improvement programs. Williams discussed the yield increases for rice and soybeans since the 1950's and mentioned some specific rice varieties developed in Arkansas that have been profitable. The station considers the control of weeds to be a prime research target in

the rice program, and has also worked with fertilizers specific to rice improvement. (II: pp. 921–922)

Congressman Brown questioned **Dr. T. W. Edminster,** Administrator of the Agricultural Research Service, about the possibility that in producing highly specialized strains "we narrow the gene pool considerably and make the productive strain much more susceptible [to disease]." Edminister noted that the recent corn blight had brought attention to this problem and in the last two or three years there have been program changes. He stated, "our breeders have been taking entirely new tacks in developing their breeding plants to broaden that pool. We've also had increases in our appropriations to increase our search for new genetic materials, particularly from areas where the hybrids were forcing out the indigenous plant material, and we were concerned it would be lost for all time." (II: pp. 125–126)

In response to a similar question **Dr. Thomas Ronningen** of the Cooperative State Research Service discussed some of the work being done in genetic vulnerability research. Ronningen stated that in response to the corn blight threat, Cornell University developed approximately 100 breeding lines of corn which were distributed in the corn industry. In addition, they developed a multiplasm concept that would provide diversity in the cytoplasm, as well as in the genetic makeup of corn. Ronningen also pointed out that the "Agricultural Research Service is in the lead role in collecting diverse germ plasms. Their organization is much better suited to organizing the means to capture the diversity in genetic germ plasm, but with help from the States." (II: p. 141)

DEFENSIVE RESEARCH

Several witnesses discussed the fact that, particularly in industry, an increasing amount of research is conducted in such areas as "toxicology, pharmacology, conformance to regulations, and dealing with . . . nutritional problems. . . ." (Clausi, II: p. 292) **Dr. R. J. Aldrich** of the Agricultural Research Institute stated that "this is in response to a growing number of government laws and regulations adopted to enhance environmental quality and assure human safety and which additionally seek to regulate fundamental agricultural activities, that is the use of land, water, labor, equipment, chemicals, and plant varieties." (II: p. 231) **Dr. Karl F. Mattil** of Texas A&M University cited a recent Delphi survey of the leaders in the food industry which suggested that while industry expenditure in R. & D. may increase over the next decade "the great preponderance of their expenditures will be for defensive purposes." (II: p. 321) It was believed that this would result in a corresponding drain on funds for "research designed to increase and improve the supply of agricultural products." (Aldrich, II: p. 231)

In addition to the efforts of private industry in this area the role of the National Center for Toxicological Research was covered by its Director, **Dr. Morris Cranmer.** He explained that a large part of the Center's program focused on insecticides, herbicides, food additives and growth promotants, all of which are important to agricultural development. Cranmer stated that one of their underlying goals was to provide "an improved means for estimation of risk to man and

an improved ability to extrapolate from animal data to man." He also listed some of the specific research activities of the Center which included: low-level dose response studies with carcinogenic agents (benzidine for example); comparative metabolism studies; dose finding studies for DES; and studies concerning the herbicide, 2,4,5-T. (II: p. 914)

AGRICULTURE AND ENERGY RESEARCH

Although energy research was described as a relatively new priority for agricultural research, several ongoing programs were identified during the hearings. **Dr. W. A. LePori** of Texas A. & M. University pointed out that energy for pumping irrigation water represents the largest single energy input in Texas agricultural production and that more than three-fourths of the total energy for this is used in the form of natural gas. As a result, natural gas research is a very important part of the Texas Agricultural Experiment Station's program. LePori discussed one project for the Texas High Plains which he said "shows that with natural gas curtailments below area requirements, irrigated acreage declines about the same percentage as the curtailment, and percentage decline in producer net returns are about one-half the percentage curtailment." (II: p. 997)

A second study by TAES scientists investigated the expected effect of rising natural gas prices on consumption of natural gas, irrigated acres, and agricultural output for a sub-area of the Texas high plains. LePori stated, "results indicate that minor adjustments in crop production patterns occur as natural gas prices reach $0.91 per 1,000 cubic feet. The first major adjustments occur when the price becomes $2.15 per 1,000 cubic feet." (II: p. 997)

The Department of Agriculture provided an outline of their energy-related research work most of which, they pointed out, is done in cooperation with other Federal, State, and local agencies. Programs included research into the use of crop residues and animal wastes as potential energy sources, support of Energy Research and Development Administration research in solar energy, and support of Environmental Protection Agency research into the reclamation of lands affected by mining.

Information was also supplied on research being done by ARS on the substitution of petroleum-derived hydrocarbons by agricultural products. For example, the conversion of cereal starch into a chemical suitable for use as a rubber reinforcement to replace carbon black filled rubber which is based on natural gas and petroleum. (Ronningen, II: p. 148; Edminster, II: pp. 118–119)

In other testimony it was also mentioned that research is being done on the energy requirements to produce natural fiber versus the requirements to produce synthetic fibers. (Martin, II: p. 909)

FOREIGN PROGRAMS

Edminster discussed the Agricultural Research Service's role as "a unique focal point in agricultural research expertise in the international arena." He pointed out that ARS coordinates and services a number of activities involving ARS scientists as well as those of other agencies. Programs administered by ARS include: special for-

eign currency research; tropical and subtropical research; in-house research at several foreign locations; technical support of the Agency for International Development of the Department of State; and several bilateral scientific agreements. (II: pp. 71–72)

MARKETING METHODS RESEARCH

Congressman Thornton questioned Edminster on the current research efforts in the area of marketing methods or procedures. Edminster responded that USDA had for several years wanted to increase exports of citrus, vegetable and other commodities to Europe but those being exported were not always acceptable on arrival, having been damaged in transit. As a solution to this problem a laboratory was established in Rotterdam, in about 1969, to act as a receiving station or laboratory. Edminster described how the program works: "coupled with our research at this end, we would select certain varieties and types of crops that we felt would ship best. Then we tested a number of different types of containers, packaging techniques, methods of putting them into containers, humidity and temperature controls that are necessary, and any preshipment treatment that might be necessary to hold down disease. These containers, with the fruit and vegetables, were then instrumented and shipped to the laboratory. These were taken out and the materials very carefully assessed." This program was described as a "tremendous step in enhancing our export capability." (II: p. 126)

In the area of domestic marketing procedures Congressman Thornton asked Mattil if any research was being done on how to get food from the farmer to the consumer more economically. Mattil said that there is some research in this area but at a low level. He explained that this is in the area of food science and engineering where very limited funds are available. (II: p. 351)

PEST MANAGEMENT RESEARCH

The Agricultural Research Service Administrator discussed pest management research as an area in which there has been an increasing amount of work for the past 10 or 20 years. He stated that "much of the increase has been shifting away from our chemical techniques toward the biological and related approaches of pest control." Specifically, he pointed out that research is being done on the use of parasites, predators, various hormones, kairimones, pheromones, and other attractants as means of better pest control. Chemosterilents and isotopic sterilization of insects are also being researched in their pest management program. (II: p. 112)

Dr. Perry Adkisson, Head of the Department of Entomology at Texas A. & M. University, described their "integrated pest management project." He stated, "in this system all known pest suppression measures, including biological, cultural and chemical practices are utilized in an economical and environmentally compatible way to keep pest populations below crop damaging levels.... The system is designed to apply a number of control measures against a pest each at the right time and in the right way and at least cost to the producer." (II: p. 959)

In Arkansas, pest management research was listed as one of many areas of R. & D. being carried on in 33 regional projects. Included in a list of the research station's accomplishments was the fact that, "Pest management research on insects has given Arkansas one of the lowest levels of losses to the boll weevil of the traditional cotton-producing States." (Martin, II: p. 898)

REMOTE SENSING RESEARCH

Dr. Chris J. Johannsen of the University of Missouri discussed a project funded by the University's Rural Development Center which produced an index of aerial photography and space images for the State of Missouri. Johannsen pointed out that although such an index is not a new research development it would serve to familiarize farmers with the usefulness of remote sensing techniques and perhaps lead to acceptance of satellite imagery as an aid to farm management in the future. (II: pp. 699–700)

Mr. Dale Starkey of the Missouri Department of Conservation described a joint project of the department and the U.S. Forest Service on high and low altitude mapping of northwest Missouri. Starkey stated that the three main objectives of the program were: to map the forest resources of the area; inventory and analyze the forest wildlife habitat conditions; and, assess the existing forest watershed conditions by conducting an erosion and sedimentation survey of the area. (II: p. 789)

Current use of satellite data in a soil survey program was described by **Mr. Ivan D. Persinger** of the Missouri Soil Conservation Service (SCS). At the national level, Persinger described a project which involves mapping of the major land resource areas of the entire United States. On the State level, the SCS is working on a general soil map for Missouri. Persinger pointed out that by using soil survey reports, geology maps and topographic maps they are able to give a better alinement of general soil area boundaries. He also described work underway at the Laboratory for Applied Application of Remote Sensing (LARS) which involves computer processing of satellite images which can yield digitized watershed boundaries, even for individual farms. (II: pp. 801–802)

Dr. Norton Strommen of the National Oceanic and Atmospheric Administration Center for Climatic and Environmental Assessment discussed their use of meterological satellite data and LANDSAT images on the Large Area Crop Inventory Experiment (LACIE) project. Specifically, he described their project to develop yield estimations of the wheat-producing areas on a global basis. Strommen stated that the Center has a model in operation producing wheat yield estimates for the Great Plains. In addition, models are ready for Canada, Russia, Australia, and Argentina and it was hoped by the spring of 1976 to have them for China and India as well. In another project, the Center used satellite outputs to monitor frequencies of precipitation in the Carribean area at the request of the State Department. The State Department used the information for their work in determining eligibility for aid. (II: p. 813)

Dr. E. C. A. Runge, Chairman of the Department of Agronomy, University of Missouri, described the use of satellite images in the LACIE project to follow the corn crop. Based on data they had obtained on weather changes, and so forth, it was possible to establish relatively accurate yield models. Runge presented model predictions and actual yields for the years 1901 through 1972. For 1972 the agreement between the model prediction yield (103 bushels per acres in six midwest States) and actual yield (100 bushels) was impressive. (II: pp. 820–821)

Dr. Dudley Smith, Assistant Director of the Texas Experiment Station described their work with the Johnson Space Center on a program in the Great Plains corridor. He stated. "we have roughly 100 million acres infested with brush and the challenge is how we can use remote sensing as a monitoring device for practical guidelines in managing this vast amount of land." (II: p. 956)

Dr. Wayne L. Decker, Chairman of the Department of Atmospheric Science at the University of Missouri stated that "remote sensing offers the only opportunity that the meterologist has to sense the total atmosphere . . . including the extent of cloud cover, wind vectors, vertical temperature profiles, cloud conditions, and the temperature of the Earth." Decker cited two recent studies by the Agricultural Research Institute and the National Academy of Sciences which called for a better weather information system for farmers. (II: pp. 830; 847)

A question was asked of **Dr. John Gohagen** of Washington University, St. Louis, during the hearings as to what kind of system was being developed to make satellite information readily available. Gohagen stated that a proposal is currently being looked at for a USDA-based system for the delivery of agriculturally related information gathered by satellite to the agricultural community. He went on to note, "we are looking at that as well as a number of other alternatives which we are generating ourselves." (II: p. 885)

SELECTIVE EXAMPLES OF FOOD-RELATED RESEARCH

In addition to the examples of ongoing research projects discussed above, the Subcommittees were presented with a large amount of information on specific types of food-related research conducted by numerous organizations and agencies. Much of this information was made available to the Subcommittees as part of the hearing record. Other information was obtained from contacts made after the hearings and during the preparation of this report. Some of the material was solicited, some was not.

Many of the organizations and agencies which provided this information were very specific in terms of the types of research supported or performed. Others grouped their efforts into major classifications such as "animal production research." The table below is an accumulation of this diverse information.

The table is intended to highlight some of the various kinds of research activities conducted by organizations and agencies other than the State Agricultural Experiment Stations and the universities at which these stations are located. The public research system as a whole is presented in less detail than would be appropriate in any inclusive list research efforts. However, the body of this report contains a significant amount of information on the public research system, and additional information is readily available from the Current Research Information System or the Smithsonian information systems.

It should be emphasized that the following listing is not intended to be anything more than a very selective presentation of a number of areas of food-related research supported in Fiscal Year 1976. It should be valuable for those unfamiliar with the breadth of research efforts which fall into the category of food-related agricultural research, or for those interested in obtaining additional information on specific areas of research.

TABLE I.—SELECTIVE EXAMPLES OF FOOD-RELATED RESEARCH, FISCAL YEAR 1976

Research subject and supporting and/or performing organizations	Amount of funds in fiscal year 1976 (millions)	Reference Nos.[1]
Agrichemicals: Boyce Thompson Institute (2)		12
Agricultural economics:		
Agency for International Development, Department of State (3)	1.0	10
Midwest Research Institute (3)	.08	19
Agrimod—mathematical dynamical simulation modeling of agricultural production: Systems Control, Inc. through Directorate for Scientific, Technological and International Affairs, National Science Foundation (2)		27
Animal production:		
Agricultural Research Service, USDA (3)	43.0	1
Environmental Protection Agency (3)	1.0	18
Aquaculture: National Oceanic and Atmospheric Administration, Department of Commerce (2)		8
Arid agricultural: Arizona State University (2)		55
Beef production:		
Research Applied to National Needs, National Science Foundation (2)		11
Cooperative State Research Service, USDA (2)		50
Bioconversion technology studies: Biomedical and Environmental Divison, Energy Research and Development Administration	4.9	13
Boll weevil eradication—evaluation program: Directorate for Scientific, Technological, and International Affairs, National Science Foundation for Office of Management and Budget (2)		27
Brush control: Texas Tech University (2)		56
Climate—effect on agriculture: C. F. Kettering Foundation (2)		23
Constraints on agricultural research: Directorate for Scientific, Technological and International Affairs, National Science Foundation (2)		27
Consumption—habits, choices: Department of Defense	1.7	5
Cooperatives—research on:		
Farmer Cooperative Service, USDA (2)		25
Southern Illinois University (2)		57
Costs of nutritious food—lowering of: Agency for International Development, Department of State (3)	.2	10
Cotton byproducts: Farmer Cooperative Service, USDA (2)		25
Crop improvement: State Agricultural Experiment Station, Arkansas (2)		30
Crop improvement—genetic pool:		
Agricultural Research Service, USDA (2)		32
Cooperative State Research Service, USDA (2)		33

See references and foonotes at end of table.

TABLE I.—SELECTIVE EXAMPLES OF FOOD-RELATED RESEARCH FISCAL YEAR 1976—Continued

Research subject and supporting and/or performing organizations	Amount of funds in fiscal year 1976 (millions)	Reference Nos.[1]
Crop improvement—see also "rice" and "sorghum."		
Crop production.		
Environmental Protection Agency	1.3	18
C. F. Kettering Foundation, conference support	.02	23
Arizona State University [2]		55
USDA	103.1	59
Dairy cooperatives: Farmer Cooperative Service, USDA [2]		25
Developing countries—food irradiation: Department of Defense [3]	.02	5
Developing countries—production: Agency for International Development, Department of State [3]		10
Disease—Animal:		
Rockefeller Foundation [2]		17
Agricultural Research Service, USDA [2]		28
Disease—plant:		
Boyce Thompson Institute [2]		12
Agricultural Research Service, USDA [2]		28
Ecological: Biomedical and Environmental Division, Energy Research and Development Administration [4]	34.7	13
Energy—agriculture related:		
State Agricultural Research Service [2]		35
Agricultural Research Service, USDA [2]		36
USDA [2]		37
Environmental quality: Cooperative State Research Service, USDA	.482	50
Farm management studies.		
Rockefeller Foundation	.25	17
Kellogg Foundation [3]	.1	20
Farmer Cooperative Service, USDA [2]		25
Fertilizer:		
Tennessee Valley Authority [3]	3.0	26
Agricultural Research Service, USDA [2]		41
Fish production: National Oceanic and Atmospheric Administration, Department of Commerce [2]		8
Fish production—see marine system production.		
Fishery habitat investigations: National Oceanic and Atmospheric Administration (Department of Commerce) [2]		8
Food marketing: Agricultural Research Service, USDA [2]		39
Food preservation:		
Department of Defense	6.3	5
Biomedical and Environmental Division, Energy Research and Development Administration	.1	13
Food processing:		
Department of Defense [5]	1.2	5
Environmental Protection Agency	.65	18
Agricultural Research Service, USDA [2]		28
Food processing efficiency: National Science Foundation [2]		7
Food sciences programs: Kellogg Foundation	.05	20
Forage production:		
Cooperative State Research Service, USDA [2]		50
Arizona State University [2]		55
Fuels from biomass: Solar Energy Division, Energy Research and Development Administration [4]	.175	16
Genetic vulnerability: Cooperative State Research Service, USDA	.5	50
Grain: Farmer Cooperative Service, USDA [2]		25
Grain—moisture: National Bureau of Standards, Department of Commerce	.35	9
Growth regulator—plants: Southern Illinois University [2]		57
Herbicide: Southern Illinois University [2]		57
Herbicide—impact of elimination of: Economic Research Service, USDA [2]		22
Horticultural—vegetable and fruit production: Texas Tech University [3]		56
Husbandry: Kellogg Foundation [3]	.2	20
Insect control—microbial: Boyce Thompson Institute [2]		12
Insect control—see pest management:		
Insecticides—viral: Boyce Thompson Institute [2]		12
International agricultural:		
Arizona State University [2]		55
Agricultural Research Service, USDA [2]		38
Ford Foundation	3.553	58
Agency for International Development, Department of State [3]		10
Irrigation—environmental degradation: Environmental Protection Agency	1.3	18
Irrigation—systems, efficiency:		
Agricultural Research Service, USDA [2]		28
Arizona State University [2]		55
United States Geological Survey, Department of the Interior	.1	24
Land evaluation: Southern Illinois University [2]		57
Land management:		
Cooperative State Research Service, USDA	.8	50
Economic Research Service, USDA [2]		22
Research Applied to National Needs, National Science Foundation [2]		11
Tennessee Valley Authority	.6	26
United States Geological Survey, Department of the Interior	1.8	24

See references and foonotes at end of table.

TABLE I.—SELECTIVE EXAMPLES OF FOOD-RELATED RESEARCH FISCAL YEAR 1976—Continued

Research subject and supporting and/or performing organizations	Amount of funds in fiscal year 1976 (millions)	Reference Nos.[1]
Livestock production:		
Agency for International Development, Department of State[3] (3)	1.4	10
Agricultural Research Service, USDA (3)		28
Cooperative State Research Service, USDA	1.425	50
Farmer Cooperative Service, USDA (3)		25
Kellogg Foundation (3)	.1	20
Southern Illinois University (2)		57
Texas Tech University (2)		56
Lone star tick: Cooperative State Research Service, USDA	.075	50
Maize: Rockefeller Foundation (3)		17
Marine biology: Nationald Oceanic an Atmospheric Administration, Department of Commerce (3)		8
Marine systems productivity: National Science Foundation (3)		7
Marketing:		
Private industry (6)		52
Southern Illinois University (2)		57
Marketing—see "food marketing."		
Mathematical modeling—see "agrimod."		
Meat product: Department of Defense	.3	5
Metric system and food packaging: National Bureau of Standards, Department of Commerce	.01	9
Military food needs: Department of Defense (3)	2.6	5
Nitrogen fixation:		
Biological, Behavioral and Social Sciences Division, National Science Foundation (3)	1.3	6
C. F. Kettering Foundation (3)		23
Research Applied to National Needs, National Science Foundation (3)		11
Rockefeller Foundation	1.2	17
Nutrition and food: Cooperative State Research Service, USDA	.715	50
Nutrition requirements:		
Private industry (6)		51
USDA	13.7	59
Nutrition—animals: Southern Illinois University (2)		57
Nutrition—biochemical and metabolic:		
Department of Defense	1.4	5
National Institutes of Health, Department of Health, Education, and Welfare (3)	12.0	2
Nutrition—diseased states: National Institutes of Health, Department of Health, Education, and Welfare (3)	10.0	2
Nutrition—food—mainly carcinogenesis: National Institutes of Health, Department of Health, Education, and Welfare (3)	.6	2
Nutrition—food nutrient content:		
National Institutes of Health, Department of Health, Education, and Welfare (3)	.2	2
Agricultural Research Service, USDA	.1	1
Nutrition—organ system function: National Institutes of Health, Department of Health, Education, and Welfare (3)	8.0	2
Nutrition—relationship to soil: Agricultural Research Service, USDA (3)		28
Nutrition—toxicology: National Institutes of Health, Department of Health, Education, and Welfare (3)	.5	2
Nutrition studies—education: Agency for International Development, Department of State (3)	.08	10
Nutrition studies—labeling, nutrient data bank, consumer information: Food and Drug Administration, Department of Health, Education, and Welfare	15.3	3, 4
Nutrition studies—world perspective: National Academy of Sciences through Directorate for Scientific, Technological, and International Affairs, National Science Foundation	1.2	2
Oil seeds—crushing capacity: Farmer Cooperative Service, USDA (3)		25
Organic farming techniques: Research Applied to National Needs, National Science Foundation (3)		11
Parasitic contol—animals: Agricultural Research Service, USDA (3)		28
Parasitism—plants—see "disease, plants."		
Pest management:		
Agricultural Research Service, USDA	70.7	40
Arizona State University (2)		55
Cooperative State Research Service, USDA	.5	50
Environmental Protection Agency	1.5	18
Rockefeller Foundation 7	.45	17
State Agricultural Experiment Station, Arkansas (3)		30
Texas A. & M. University (2)		42
Texas Tech University (2)		56
Pesticide:		
Boyce Thompson Institute (3)		12
Environmental Protection Agency	6.2	18
Economic Research Service, USDA (3)		22
Food and Drug Administration, Department of Health, Education, and Welfare	.3	4
National Science Foundation (3)		7
Southern Illinois University (2)		57
Pesticide—residues in food: Agricultural Research Service, USDA (3)		28
Photosynthesis:		
Biological, Behavioral, and Social Sciences Division, National Science Foundation (3)	4.0	6
Biomedical and Environmental Division, Energy Research and Development Administration (4)	4.9	13
C. F. Kettering Foundation (3)		23
Plant physiology:		
Biomedical and Environmental Division, Energy Research and Development Administration (4)	4.9	13
Southern Illinois University (2)		57

See references and foonotes at end of table.

TABLE I.—SELECTIVE EXAMPLES OF FOOD-RELATED RESEARCH, FISCAL YEAR 1976—Continued

Research subject and supporting and/or performing organizations	Amount of funds in fiscal year 1976 (millions)	Reference Nos.[1]
Plant production:		
Agricultural Research Service, USDA [3]	.8	1
Biomedical and Environmental Division, Energy Research and Development Administration (4)	4.9	13
Southern Illinois University (2)		57
Policy studies—agriculture: Kellogg Foundation	.08	20
Pollutant effects—on man, animals: Environmental Protection Agency	2.5	18
Pollutant effects—on crops:		
Biomedical and Environmental Division, Energy Research and Development Administration (4)	34.7	13
Boyce Thompson Institute (2)		12
Pollutant effects—on food nutrition: Agricultural Research Service, USDA (2)		28
Pork production: Cooperative State Research Service, USDA (2)		50
Potato. Rockefeller Foundation (2)		17
Poultry production: Agricultural Research Service, USDA (2)		28
Product development: Private industry (4)		53
Product evaluation: Midwest Research Institute (3)	.01	19
Production—food:		
Agency for International Development, Department of State (3)	2.4	10
Agricultural Research Service, USDA (2)		28
Private industry (4)		54
Protein: Texas A. & M. University (2)		46
Protein—nonconventional: Research Applied to National Needs, National Science Foundation (2)		11
Range management:		
Arizona State University (2)		55
Cooperative State Research Service, USDA (2)		50
Remote sensing—farm management: University of Missouri (2)		43
Remote sensing—forestry: Department of Conservation, Missouri and Forest Service, USDA (2)		44
Remote sensing—soil conservation: Soil Conservation Service, Missouri (2)		45
Remote sensing—yield estimations: National Oceanic and Atmospheric Administration, Department of Commerce (2)		47
Reproduction physiology: Southern Illinois University (2)		57
Rice		
State Agricultural Experiment Station, Arkansas (2)		31
Rockefeller Foundation (2)		17
Rice—lysine enhancement: Boyce Thompson Institute (2)		12
Safety—food: Agricultural Research Service, USDA (2)		28
Salmon production: National Bureau of Standards, Department of Commerce (3)	.07	9
Soil management:		
Agricultural Research Service, USDA (2)		28
Cooperative State Research Service, USDA	.2	50
Texas Tech University (2)		56
Soil management—tropical: Agency for International Development, Department of State (2)		10
Soil pollution/toxicity: Biomedical and Environmental Division, Energy Research and Development Administration (4)	34.7	13
Soil research: United States Geological Survey, Department of the Interior	.09	24
Solar—crop/grain drying, shelter, greenhouses: Solar Energy Division, Energy Research and Development Administration (10)	1.8	13, 15
Sorghum:		
Agency for International Development, Department of State (2)		10
Texas Tech University (2)		56
State Agricultural Experiment Station, Texas (2)		29
Soybean:		
Cooperative State Research Service, USDA	.5	50
Southern Illinois University (2)		57
Standards—leaf analysis and permeation of foodwraps: National Bureau of Standards, Department of Commerce [3]	.1	9
Statistical methodology—food Statistics: Statistical Reporting Service, USDA	.5	21
Storage—fruits and vegetables: Department of Defense	.02	5
Sunflower—for food: Texas Tech University (2)		56
Taro: Cooperative State Research Service, USDA to University of Hawaii	.075	50
Toxicity—food/plants:		
Biomedical and Environmental Division, Energy Research and Development Administration (4)	34.7	13
National Center for Toxicological Research, Department of Health, Education and Welfare (3)	20.0	34
Transportation of farm produce:		
Agricultural Research Service, USDA (2)		28
Farmer Cooperative Service, USDA (2)		25
Transportation of food: Cooperative State Research Service, USDA	.5	50
Transportation—rural: Southern Illinois University (2)		57
Waste usage—animal: Environmental Protection Agency (2)		18
Waste usage—animal and plant: USDA (2)		49
Water management:		
Agency for International Development, Department of State (2)		10
Agricultural Research Service, USDA (2)		28
Texas Tech University (2)		56
United States Geological Survey, Department of the Interior	3.13	24
Weather modification: Research Applied to National Needs, National Science Foundation (2)		11
Weather modification—see "climate."		
Wheat: Rockefeller Foundation (2)		17
Wind energy—agricultural machinery: Solar Energy Division, Energy Research and Development Administration	1.276	14

See references and foonotes at end of table.

REFERENCES

1. Taken from NSF publication 75-330, "An Analysis of Federal R. & D. Funding by Function", fiscal year 1976 p 70,
2. II: p. 1052-1053.
3. II: p. 1071-1072.
4. II: p. 1026.
5. II: p. 1043-1044.
6. II: p. 1127.
7. II: p. 1027.
8. NOAA, National Marine Fisheries Service, Mr. Leonard Pass.
9. II: p. 1039.
10. II: pp. 1098-1106.
11. NSF, Richard Warder.
12. Boyce Thompson Institute for Plant Research, Inc., 52d Annual Report, New York, 1975.
13. II: pp. 1112-1117.
14. ERDA, SE Division, Louis V. Divone.
15. ERDA, SE Division, William Cherry.
16. ERDA, SE Division, Henry Bungay.
17. Rockefeller Foundation, John Pino.
18. II: pp. 1119-1124.
19. Midwest Research Institute, Charles Romine.
20. Kellog Foundation, Gary W. King.
21. SRS of USDA, Kibler.
22. ERS of USDA, Alan Johnson.
23. C. F. Kettering Foundation, Marvin Lanborg.
24. Appendix A, pp. 1083-1084. Note best information available at time of report was for fiscal year 1975.
25. FCS of USDA, Marshal Goodwin.
26. II: p. 1131. Note these are 1974 figures but TVA stated on p. 1130 that they expected the level to remain near the $3,000,000 mark in this program.
27. Information obtained from R. Staples and R. Warder of NSF.
28. Information on research categories at ARS, USDA provided by B. Wimmer.
29. F. Miller and L. Rooney, II; pp. 972-994.
30. J. Martin, II; pp. 897-898.
31. F. Williams, II; pp. 920-940.
32. T. Edminster, II; pp. 126.
33. T. Ronnigen, II; p. 141.
34. M. Cranmer, II; pp. 912-919. Note the amount, given on p. 918, was an approximate number.
35. W. LePori and R. Lacewell, II; pp. 996-1017.
36. T. Edminster, II; pp. 117-119 and T. Ronnigen, II; pp. 152-153.
37. Information submitted by T. Ronnigen, II; p. 148.
38. T. Edminster, II; pp. 71-72, 105-106.
39. T. Edminster, II; p. 126.
40. T. Edminster, II; pp. 111-114. Note figures are for fiscal year 1975.
41. T. Edminster, II; pp. 112, 115-116.
42. P. Adkisson, II; pp. 958-962.
43. C. Johannsen, II; pp. 698-702.
44. D. Starkey, II; pp. 789-800.
45. I. Persinger, II; pp. 801-811.
46. K. Mattil, II; pp. 336-346.
47. N. Strommen, II; pp. 812-814.
48. E. Runge, II; pp. 820-828.
49. T. Edminster, II; pp. 118-119.
50. CSRS, USDA; information supplied by Elizabeth Davis.
51. See table 4, on II; p. 1139. These numbers are based on estimated projections for 1975 using survey results obtained by the ARI from private industry. Of $393,000,000 in estimated R. & D. expenditures for private industry shown in table I of this report then, about $16,000,000 (or 4 percent) could be expected to be spent on human nutrition research.
52. Ibid. For marketing the estimated amount is also 4 percent, or about $16,000,000.
53. Ibid. For product development the estimated expenditures for 1975 were 27 percent, or about $106,000,000 of the $393,000,000 shown in table I of this report.
54. Ibid. For production efficiency research the estimate for 1975 was 24 percent, or about $94,000,000 of the estimated $393,000,000 total.
55. Arizona State University information supplied by Dr. Richard Chalquest, Director of the Division of Agriculture.
56. Texas Tech University information provided by the office of Dr. Anson Bertrand, Dean of the College of Agricultural Sciences.
57. Southern Illinois University (Carbondale) information provided by Dr. Gilbert Kroening, Dean of the School of Agriculture.
58. Ford Foundation information obtained from Dr. Lowell Hardin of the International Division. Note that these are 1975 data.
59. II; p. 138.

FOOTNOTES

[1] See list of references above.
[2] Amount of funds in FY 1976 unknown.
[3] Amount of funds listed is approximate.
[4] Amount of funds listed is partial.
[5] Funds awarded to ARS and Hamilton Standard.
[6] Estimated at 4 percent of total effort.
[7] Funds awarded to SAES.
[8] Estimated at 27 percent of total effort.
[9] Estimated at 24 percent of total effort.
[10] Funds awarded to ARS.

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APPENDIX C

List of U.S. Academic Institutions Involved In Agricultural Research

APPENDIX C

List of U.S. Academic Institutions Involved in Agricultural Research

STATE AGRICULTURAL EXPERIMENT STATIONS

Auburn University (Alabama)—Auburn.
University of Alaska—Fairbanks.
University of Arizona—Tucson.
University of Arkansas—Fayetteville.
University of California—Berkeley.
Colorado State University—Fort Collins.
University of Connecticut—Storrs.
New Haven, Connecticut (not connected with a university).
University of Delaware—Newark.
University of Florida—Gainesville.
University of Georgia—Athens.
University of Guam—Agana.
University of Hawaii—Honolulu.
University of Idaho—Moscow.
University of Illinois—Urbana.
Purdue University (Indiana)—West Lafayette.
Iowa State University—Ames.
Kansas State University—Manhattan.
University of Kentucky—Lexington.
Louisiana State University and A&M College—Baton Rouge.
University of Maine—Orono.
University of Maryland—College Park.
University of Massachusetts—Amherst.
Michigan State University—East Lansing.
University of Minnesota—St. Paul.
Mississippi State University—Mississippi State.
University of Missouri—Columbia.
Montana State University—Bozeman.
University of Nebraska—Lincoln.
University of Nevada—Reno.
University of New Hampshire—Durham.
Rutgers University (New Jersey)—New Brunswick.
New Mexico State University—Las Cruces.
Cornell University (New York)—Ithaca.
Geneva, New York (not connected with a university).
North Carolina State University—Raleigh.
North Dakota State University—Fargo.
Ohio State State University—Columbus.
Oklahoma State University—Stillwater.
Oregon State University—Corvallis.
Pennsylvania State University—University Park.
University of Puerto Rico—Rio Piedras.
University of Rhode Island—Kingston.
Clemson University (South Carolina)—Clemson.
South Dakota State University—Brookings.
University of Tennessee—Knoxville.
Texas A&M University—College Station.
Utah State University—Logan.
University of Vermont—Burlington.
Virginia Polytechnic Institute and State University—Blacksburg.
College of the Virgin Islands—St. Croix.
Washington State University—Pullman.
West Virginia University—Morgantown.
University of Wisconsin—Madison.
University of Wyoming—Laramie.

1890 COLLEGES AND TUSKEGEE INSTITUTE

Alabama A&M University—Normal.
University of Arkansas—Pine Bluff.
Delaware State College—Dover.
Florida A&M University—Tallahassee.
Fort Valley State College (Georgia)—Fort Valley.
Kentucky State University—Frankfort.
Southern University (Louisiana)—Baton Rouge.
University of Maryland—Eastern Shore—Princess Anne.
Alcorn State University (Mississippi)—Lorman.
Lincoln University (Missouri)—Jefferson City.
North Carolina A&T State University—Greensboro.
Langston University (Oklahoma)—Langston.
South Carolina State College—Orangeburg.
Tennessee State University—Nashville.
Prairie View A&M University (Texas)—Prairie View.
Virginia State College—Petersburg.
Tuskegee Institute (Alabama).

NON-LAND GRANT COLLEGES AND UNIVERSITIES OFFERING ACADEMIC PROGRAMS IN THE AGRICULTURAL SCIENCES AND OR RENEWABLE NATURAL RESOURCES [1]

Arkansas State College—Jonesboro.
Humboldt State University (California)—Arcata.
California State University—Fresno.
California State Polytechnic University—San Luis.
Southern Illinois University—Carbondale.
Western Illinois University—Macomb.
Illinois State University—Normal.
Morehead State University (Kentucky)—Morehead.
Eastern Kentucky University—Richmond.
Southwest Louisiana University—Lafayette.
Louisiana Technical University—Ruston.
Northwest Missouri State University—Maryville.
University of Montana—Missoula.
Oklahoma Panhandle State College—Goodwell.
Austin Peay State University (Tennessee)—Clarksville.
Middle Tennessee State University—Murfreesboro.
Sul Ross State Univerity (Texas)—Alpine.
West Texas State University—Canyon.
East Texas State University—Commerce.
Sam Houston State University (Texas)—Huntsville.
Texas A and I University—Kingsville.
Texas Technical University—Lubbock.
Stephen F. Austin State University (Texas)—Nacogdoches.
Southwest Texas State University—San Marcos.
Tarleton State College (Texas)—Stephenville.
University of Wisconsin—River Falls.
University of Wisconsin—Stevens Point.
University of Arkansas—Monticello.
Arkansas Polytechnic College—Russellville.
California State University—Chico.
California State Polytechnic University—Pomona.
Fort Lewis College (Colorado)—Durango.
Fort Hays State College (Kansas)—Fort Hays.
Western Kentucky University—Bowling Green.

[1] List of colleges was obtained from the *Statistical Report—1975* of the American Association of University Agricultural Administrators. The two groups of schools represent, first, those who had active research programs funded in 1975, and second, schools that received no research funding in 1975.

NON-LAND GRANT COLLEGES AND UNIVERSITIES OFFERING ACADEMIC PROGRAMS IN THE AGRICULTURAL SCIENCES AND/OR RENEWABLE NATURAL RESOUCES—Continued

Murray State University (Kentucky)—Murray.
Southeast Louisiana University—Hammond.
Northeast Louisiana University—Monroe.
Northwest Louisiana University—Natchitoches.
Nichols State University (Louisiana)—Thibodaux.
Western Michigan University—Kalamazoo.
Southeast Missouri State University—Cape Girardeau.
Northeast Missouri State University—Kirkville.
Southwest Missouri State University—Springfield.
Central Missouri State University—Warrensburg.
Tennessee Technical University—Cookeville.
University of Wisconsin—Platteville.

APPENDIX D

Hearing Particulars

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APPENDIX D

Hearing Particulars

The following is a list of the people who appeared before the Subcommittees in their ten days of hearings held in June, September and October of 1975. There were 50 participants in all representing Federal and State government, universities, private industry, and private non-profit research organizations. Two of the witnesses, Robert W. Long and Orville G. Bentley, appeared twice. In June, Long and Bentley presented a joint statement on behalf of the Agricultural Research Policy Advisory Committee (ARPAC) in their capacity as cochairmen of that committee. Bentley testified again in September on behalf of ARPAC, reporting on the ARPAC sponsored conference on research to meet United States and world food needs held in Kansas City in July 1975. Long testified again in October in his capacity as Assistant Secretary for Conservation, Research and Education of the Department of Agriculture. It should also be pointed out that two days of hearings (October 24 and 25) were held outside of Washington, D.C. Sites of these hearings were the University of Missouri in Columbia; the Federal Building in Pine Bluff, Arkansas; and Texas A&M University in College Station.

June 25, 1975:

Dr. Sylvan H. Wittwer, director of the Michigan State University Agriculture Experiment Station, appearing as chairman of the Board on Agriculture and Renewable Resources, National Academy of Sciences.

June 26, 1975:

Robert W. Long and Dr. Orville G. Bentley, cochairmen, Agricultural Research Policy Advisory Committee (joint statement).

September 23, 1975:

Dr. Sterling Wortman, vice president, The Rockfeller Foundation.

Esther Peterson, consumer adviser, Giant Food, Inc.

September 24, 1975:

T. W. Edminster, Administrator, Agricultural Research Service, U.S. Department of Agriculture.

Dr. Thomas S. Ronningen, Associate Administrator, Cooperative State Research Service, U.S. Department of Agriculture, accompanied by Dr. Edward C. Miller, Deputy Administrator, Program Operations, Evaluation and Analysis; and Dr. Clare I. Harris, Deputy Administrator, Agriculture, Rural Development, and Consumer Service Programs, U.S. Department of Agriculture.

Dr. Orville G. Bentley, cochairman, Agricultural Research Policy Advisory Committee and dean, College of Agriculture, University of Illinois, Champaign-Urbana, Illinois.

September 25, 1975:

Dr. Richard J. Aldrich, president, Agricultural Research Institute, Columbia, Mo., accompanied by William L. Brown, president, Pioneer Hi-Bred International, Inc.: Ralph E. Baumheckel, production research manager, Agricultural Equipment Division, International Harvester Co.; William L. Hollis, science coordinator, National Agricultural Chemicals Association; Harold L. Wilcke, consultant, retired corporate vice president for research, Ralston Purina Co.; and S. G. Younkin, vice president, Agricultural Research, Campbell Soup Co.

Adolph Clausi, vice president for corporate research, General Foods Corp., White Plains, N.Y.

Dr. Karl F. Mattil, director, Food Protein Research and Development Center, Texas A. & M. University, College Station, Texas.

September 30, 1975:

Hon. Frederick W. Richmond, a Member of Congress from the State of New York.

Dr. Glenn S. Pound, dean College of Agriculture and Life Sciences, University of Wisconsin, Madison, Wisconsin.

September 30, 1975—Continued

Charles A. Romine, economist, Midwest Research Institute, Kansas City, Missouri., accompanied by Bruce W. Macy, assistant director, Economics & Management Science Division; Ivan C. Smith, senior advisor for Environmental Science.

October 24, 1975:

Othal E. Brand, president, Griffin & Brand, Inc., McAllen, Texas.

Dr. Barry Commoner, director, Center for the Biology of Natural Systems, Washington University, St. Louis, Missouri.

Dr. Edward H. Glass, professor of entomology and head of department, New York State Agricultural Experiment Station, Cornell University, Geneva, New York.

October 2, 1975:

Dr. William F. Hueg, deputy vice president, Institute of Agriculture, Forestry and Home Economics, University of Minnesota, Minneapolis Minnesota.

Robert W. Long, Assistant Secretary for Conservation, Research and Education, U.S. Department of Agriculture, accompanied by Dr. David J. Ward, Research Planning and Coordination office of the Secretary, U.S. Department of Agriculture.

October 24, 1975:

Dr. Chris J. Johannsen, State Extension Agronomy Specialist—Land Use, University of Missouri, Columbia, Missouri.

Dr. David J. Barr, Department of Mining, Petroleum, and Geological Engineering, School of Mines and Metallurgy, University of Missouri, Rolla, Missouri.

Dr. John Kenneth Gohagan, assistant professor, Center for Development Technology, Washington University, St. Louis, Missouri.

Dale Starkey, Missouri Department of Conservation, Forestry Division Columbia, Missouri.

Ival D. Persinger, assistant State soil scientist, Soil Conservation Service, Columbia, Missouri.

Dr. Norton Strommen, National Oceanic and Atmospheric Administration Center for Climatic and Environmental Assessment, Columbia, Missouri.

Dr. E. C. A. Runge, professor and chairman, Department of Agronomy, University of Missouri, Columbia, Missouri.

Dr. Wayne L. Decker, chairman, Department of Atmospheric Science, University of Missouri, Columbia, Missouri.

Mr. L. C. "Clell" Carpenter, vice president, Midcontinent Farmers Association, Columbia, Missouri.

Dr. James E. Martin, vice president for agriculture, University of Arkansas, Fayetteville, Arkansas.

Dr. Morris F. Cranmer, director, National Center for Toxicological Research, Food and Drug Administration, Pine Bluff, Ark., accompanied by Dr. David Smith, executive director, National Center for Toxicological Research, Pine Bluff, Arkansas.

Francis J. Williams, resident director, University of Arakansas Rice Branch Experiment Station, Stuttgart, Ark., accompanied by Dr. Lloyd Warren, director, Arkansas Agricultural Experiment Station, Fayetteville, Arkansas.

Jack Justus, vice president, Arkansas Farm Bureau Federation, accompanied by Nick Hargrove, vice president and W. F. Wright, staff member, Arkansas Farm Bureau Federation.

October 25, 1975:

Dr. Dudley Smith, assistant director, Texas Agricultural Experiment Station, College Station, Tex.

Dr. Perry L. Adkisson, head of the Department of Entomology, Texas A. & M. University, College Station, Tex.

Dr. Frederick R. Miller, assistant professor of sorghum breeding, Soil and Crop Sciencies Department, and Dr. Lloyd W. Rooney, associate professor of cereal chemistry, Soil and Crop Sciences Department, Texas A. & M. University, College Station, Tex.

Dr. Wayne A. Le Pori, assistant professor of crop mechanization, Department of Agricultural Engineering; Dr. Charles G. Coble, assistant professor of crop mechanization, Department of Agricultural Engineering; and Dr. Ronald D. Lacewell, associate professor of resource economics, Department of Agricultural Economics, Texas A. & M. University, College Station, Tex.

APPENDIX E

The Funding and Extent of Performance of Food-Related Agricultural Research

APPENDIX E

The Funding and Extent of Performance of Food-Related Agricultural Research

Material gathered during the hearings, along with material submitted for the record, and additional data obtained for fiscal year 1976, was utilized in order to establish the sources of support for food-related research (in terms of funds provided) and the performers of that research (in terms of funds expended). The data used for this portion of the analysis is tabulated in tables I and II, and depicted graphically in figures 1, 2, and 3. These tables and graphs do not attempt to identify the authority for granting of funds—that is, the Hatch Act, and so forth. However, discussion of the particulars of funding does follow this general section, which summarizes the findings in relation to funding and performance of research for fiscal year 1976.

PUBLIC FUNDS FOR FOOD-RELATED RESEARCH TOTAL ABOUT 65 PERCENT

It was found that Federal appropriations to individual agencies for areas related to food-research accounted for about 47 percent of the funds available nationally for such research in fiscal year 1976. The States contributed another 18–19 percent, bringing the total public support to 65–66 percent. Private industry also played a significant role in the provision of funds, accounting for approximately 32 percent of the total available. Nonprofit institutions were responsible for about 1 percent of the funds, and non-land-grant universities contributed about 1–2 percent for research related to food. See figure 1, for a graphical presentation, and table I, for a complete listing of these data. Footnotes to the table explain sources of information and/or methods used to estimate figures.

TABLE I.

FUNDING OF FOOD-RELATED RESEARCH, FY 76

(million of dollars)

CLASSIFICATION	ORGANIZATION	SUBDIVISION/ PROGRAM/LABORATORY	AMOUNT OF FUNDING	REFERENCE
FEDERAL GOVERNMENT TOTAL: 584.81	Dept. of Agriculture (USDA) TOTAL: 314.99	Agricultural Research Service (ARS)	209.115	1
		Farmer Cooperative Service (FCS)	0.965	2
		Economic Research Service (ERS)	23.334	3
		Statistical Reporting Service (SRS)	0.5	4
		Cooperative State Research Service (CSRS)	81.083	5
	Dept. of Commerce (DOC)	National Bureau of Standards (NBS)	0.57	6
	TOTAL: 34.99	National Oceanic & Atmospheric Administration (NOAA) (National Marine Fisheries Service)	34.42	7
	Dept. of State (DOS) TOTAL: 49.218	Agency for International Development (AID)	49.218	8
	Dept. of Interior (DOI) TOTAL: 4.397	U.S. Geological Survey (USGS)	4.397	9

TABLE I. (continued)

CLASSIFICATION	ORGANIZATION	SUBDIVISION/ PROGRAM/LABORATORY	AMOUNT OF FUNDING	REFERENCE
	Dept. of Health, Education & Welfare (HEW)	National Insitutes of Health (NIH)	53.0	10
	TOTAL: 68.3	Food & Drug Administration (FDA)	15.3	11
	Energy Research and Development Admin. (ERDA)	Biomedical and Environment (BER)	39.7	12
	TOTAL: 43.03	Solar Energy (SE)	3.33	13
	Dept. of Defense (DOD)	U.S. Army Natick Dev. (NDC)	15.615	14
	TOTAL: 15.615	Letterman Army Inst. of Research (LAIR)		
		Programs		
	Environmental Protection Agency (EPA)	Agricultural Pollution Control (APC)	3.894	15
		Alternate Pest Management (APM)	1.5	16
	TOTAL: 14.73	Health & Ecological Effects (HEE)	6.187	17
		Effects of Pollutants (EP)	2.5	18
		Food Products Industry (FPI)	.65	19
	Tennessee Valley Authority (TVA)	In-House Programs	6.0	20
	TOTAL: 6.0			

TABLE 1. (continued)

CLASSIFICATION	ORGANIZATION	SUBDIVISION/ PROGRAM/LABORATORY	AMOUNT OF FUNDING	REFERENCE
	National Science Foundation (NSF)	Directorate for Biological, Behavioral, & Social Sciences (BBSS)	27.2	21
	TOTAL: 33.55	Directorate for Astronomical, Atmospheric, Earth, & Ocean Sciences (AAEO)	.55	22
		RANN	3.6	23
		Directorate for Scientific, Technological & International Affairs (STIA)	2.2	22, 24
	Ford Foundation (FF)	Foreign, Extra-mural Programs	3.553	25
NON-PROFIT	TOTAL: 3.553			
35 INSTITUTIONS	Rockefeller Foundation (RF)	Conquest of Hunger (COH)	7.0	26
TOTAL: 15.273	TOTAL: 7.7	Quality of Environment (QE)	.45	26
		Equal Opportunity (EO)	.25	26
	Kellogg Foundation (KF)	Foreign Projects	.176	27
	TOTAL: 0.370	American Indian Projects	.194	27

TABLE I. (continued)

CLASSIFICATION	ORGANIZATION	SUBDIVISION/ PROGRAM/LABORATORY	AMOUNT OF FUNDING	REFERENCE
	C.F. Kettering Foundation (CFK)	Yellow Springs Laboratory (YSL)	1.65	28
	TOTAL: 1.9	Extra-mural	.25	28
	Boyce Thompson Institute (BTI)	Institute for Plant Res. (from endowments) (IPR)	1.5	29
	TOTAL: 1.5			
	Mid-West Research Institute (MRI)	In House Programs	0.25	34
	TOTAL: 0.25			
	Grouped by Interest:			
PRIVATE INDUSTRY	Food Industry (1973 best available information)		268.	30
TOTAL: 393.0	Other Food-Related (Estimate only)		125.	30
STATE GOVERNMENTS	Appropriations to Non-Land Grant Universities		1.968	40
TOTAL: 230.22	Appropriations to SAES & Colleges of 1890		228.252	31
32 NON-SAES UNIVERSITIES	Nine Universities	See 33.	19.32	33
TOTAL: 19.32				
TOTAL FUNDING REPORTED: 1,242.				

TABLE II.

PERFORMERS OF FOOD-RELATED RESEARCH, FY 76
(and sources of funds)

(millions of dollars)

CLASSIFICATION	PERFORMING ORGANIZATION	PERFORMING SUBDIVISION/ PROGRAM/ LABORATORY	AMOUNT OF EFFORT, BY FUNDS	SOURCE OF FUNDS*	REFERENCE
FEDERAL GOVERNMENT TOTAL EXPENDED, IN-HOUSE RESEARCH: 351.62	Dept. of Agriculture (USDA) TOTAL EXPENDED, IN-HOUSE RESEARCH: 236.52	Agricultural Research Service (ARS)	205.728	ARS	1
			1.645	DOS; AID	8
			2.8	ERDA; SE	13
			1.558	EPA; APC	15
		Farmer Cooperative Service (FCS)	0.965	FCS	2
		Economic Research Service (ERS)	23.334	ERS	3
		Statistical Reporting Service (SRS)	0.5	SRS	4
	Dept. of Commerce (DOC) TOTAL EXPENDED, IN-HOUSE RESEARCH: 22.647	National Bureau of Standards (NBS)	0.57	NBS	6
		National Marine Fisheries Service (NOAA)	22.077	NOAA	7
	Dept. of Interior (DOI) TOTAL EXPENDED, IN-HOUSE RESEARCH: 4.782	U.S. Geological Survey (USGS)	0.385	DOS; AID	8
			4.397	USGS	9

TABLE II. (continued)

CLASSIFICATION	PERFORMING ORGANIZATION	PERFORMING SUBDIVISION/ PROGRAM/ LABORATORY	AMOUNT OF EFFORT, BY FUNDS	SOURCE OF FUNDS	REFERENCE
	Dept. of Health, Education, & Welfare	National Institutes of Health (NIH)	20.0	NIH	44
	TOTAL EXPENDED, IN-HOUSE RESEARCH: 35.3	Food & Drug Administration (FDA)	15.3	FDA	11
	Energy Research and Development Admin. (ERDA)	National Labs	27.858	ERDA; BER, SE	12, 13
	TOTAL EXPENDED, IN-HOUSE RESEARCH: 27.858				
	Dept. of Defense (DOD)	U.S. Army Natick Development Center	0.774	DOD	14
	TOTAL EXPENDED, IN-HOUSE RESEARCH: 10.774	Letterman Army Institute of Research			
	Environmental Protection Agency (EPA)	Agricultural Pollution Control	.662	EPA	15
	TOTAL EXPENDED, IN-HOUSE RESEARCH: 5.582	Health & Ecological Effects	3.465	EPA	17
		Effects of Pollutants	1.325	EPA	18
		Food Products Industry	0.13	EPA	19

TABLE II. (continued)

CLASSIFICATION	PERFORMING ORGANIZATION	PERFORMING SUBDIVISION/ PROGRAM/ LABORATORY	AMOUNT OF EFFORT, BY FUNDS	SOURCE OF FUNDS	REFERENCE
	Tennessee Valley Authority (TVA)	In-House Programs	6.0	TVA	20
	TOTAL EXPENDED, IN-HOUSE RESEARCH: 6.0				
	Unidentified Federal Agency Performers		2.162	EPA	15-19
	TOTAL EXPENDED, IN-HOUSE RESEARCH:				
	C.F. Kettering (CFK)	Yellow Springs Laboratory (YSL)	1.65	CFK	28
NON-PROFIT INSTITUTIONS	TOTAL EXPENDED, IN-HOUSE RESEARCH:1.65				
TOTAL EXPENDED, IN-HOUSE RESEARCH: 8.547	Unidentified Performers	Unidentified Performers	1.95 0.335 0.592 --	RF NSF DOC; NOAA ARS	26 21 7 36
	TOTAL EXPENDED, IN-HOUSE RESEARCH: 0.927				

TABLE II. (continued)

CLASSIFICATION	PERFORMING ORGANIZATION	PERFORMING SUBDIVISION/ PROGRAM/ LABORATORY	AMOUNT OF EFFORT, BY FUNDS	SOURCE OF FUNDS	REFERENCE
	Rockefeller Foundation (RF)	Conquest of Hunger, In-House Programs	0.77	RF	26
	TOTAL EXPENDED, IN-HOUSE RESEARCH: 0.77				
	Boyce Thompson Institute	Institute for Plant Research	1.5	BTI	29
	(BTI)		1.5	CSRS, RF, FF and Private Industry	29
	TOTAL EXPENDED, IN-HOUSE RESEARCH: 3.0				
	Mid-West Research Institute	In-House Programs	0.08	MRI	34
			0.01	STATE	
			0.07	U.S. Congress; OTA	34 34
	TOTAL EXPENDED, IN-HOUSE RESEARCH: 0.25		0.09	Private Industry	34
	Individual Performers Could Not Be Separated		368.0	Self-Funding	37
			4.06	DOD	14
PRIVATE INDUSTRY			1.761	USDA; ARS	1
			0.1	ERDA; SE	13
			3.151	DOC; NOAA	7
TOTAL EXPENDED, IN-HOUSE RESEARCH: 381.32			4.25	EPA; EP; FPI, HEE	17-19

TABLE II. (continued)

CLASSIFICATION	PERFORMING ORGANIZATION	PERFORMING SUBDIVISION/ PROGRAM/ LABORATORY	AMOUNT OF EFFORT, BY FUNDS	SOURCE OF FUNDS	REFERENCE
SAES UNIVERSITIES/COLLEGES OF 1890	Individual Universities Were Not Identified as Performers		2.064	EPA; APC	15
			0.675	EPA; APM	16
			0.881	USDA; ARS	1
			10.315	DOS; AID	8
TOTAL EXPENDED, IN-HOUSE RESEARCH: 349.37			80.737	USDA; CSRS	5
			94.672	Federal Government Total:	
			25.0	Private Industry	37, 38
			228.252	State Appropriations	31
			0.25	CFK	28
			0.10	KF	27
			1.10	RF	26
			1.45	Non-Profit Institutions Total	
NON SAES-AFFILIATED UNIVERSITIES 41	Individual Universities Were Not Identified as Performers		33.0	HEW; NIH	44
			0.242	DOS; AID	8
			0.346	USDA; CSRS	5
			0.714	DOC; NOAA	7
			0.745	USDA; ARS	1
			0.781	DOD	14
TOTAL EXPENDED, IN-HOUSE RESEARCH: 98.892			0.4	ERDA; SE	13
			12.0	ERDA; BER	12
			48.228	Federal Government, Partial Total	
			30.15	NSF	39
			19.32	Self-Funding	32
			0.728	Private Industry	40
			0.1	KF	27
			0.366	RF	26

TABLE II. (continued)

CLASSIFICATION	PERFORMING ORGANIZATION	PERFORMING SUBDIVISION/ PROGRAM/ LABORATORY	AMOUNT OF EFFORT, BY FUNDS	SOURCE OF FUNDS	REFERENCE
STATE/LOCAL GOVERNMENTS: 42	Individual Performers Were Not Identified		7.89	DOC; NOAA	7
TOTAL EXPENDED, IN-HOUSE RESEARCH: 7.89					
FOREIGN NON-PROFIT INSTITUTIONS	Individual Performers Were Not Identified		30.079	DOS; AID	8
			3.553	FF	25
			0.18	KF	27
			2.95	RF; PROGRAMS	26
TOTAL EXPENDED, IN-HOUSE RESEARCH: 37.437			0.675	RF; STUDENT-SUPPORT	26
TOTAL EXPENDITURES FOR RESEARCH REPORTED: 45 1,226					

SOURCES OF INFORMATION FOR TABLES I AND II

1. ARS, information provided by E. Hawker, Davenport, and E. Wimmer.
2. FCS, information provided by M. Goodwin.
3. ERS, information provided by A. Johnson.
4. SRS, information provided by Kibler.
5. CSRS, information provided by R. Alsmeyer.
6. DOC, II: p. 1039; information confirmed by S. Rasberry, NBS.
7. NOAA, information obtained from L. Pass.
8. AID, II: p. 1098; revised by M. Rechcigl, Jr. of AID.
9. DOI, II: p. 1093; data for fiscal year 1976 supplied by J. Place, USGS.
10. HEW, II: p. 1048; revised by Dr. M. Mehlman of NIH. The NIH also reports about $100 million going into secondary nutrition research, i.e., the effects of nutrients on various diseases, and so on. This type of research is primarily health-related and has therefore not been included in the NIH total for purposes of this report.
11. FCST Report fiscal year 1976, II: p. 1028; confirmed by Delano Merriweather of HEW.
12. ERDA, II: pp. 1114–1115; additional facts from Simpson and R. Conaway.
13. ERDA, II: pp. 1116–1117; additional data from W. Cherry and L. V. Divone.
14. DOD, II: pp. 1043–1044; and Col. Stanley C. White.
15. EPA, II: p. 1122; with additional information from Darwin Wright.
16. EPA, II: p. 1123; with additional information from Darwin Wright.
17. EPA, II: p. 1123; funding breakdown from Tom Waddell.
18. EPA, II: p. 1124; funding breakdown from Tom Waddell.
19. EPA, II: p. 1124; additional information supplied by Tom Waddell.
20. TVA, II: p. 1132.
21. NSF, II: p. 1127; reviewed by R. Staples, and Dillon.
22. NSF, information from R. Warder.
23. NSF, II: p. 1127; additional information provided by Dillon.
24. NSF, II: p. 1127; additional information from Dillon.
25. Ford Foundation, information supplied by Lowell Hardin: 1975 data.
26. Rockefeller Foundation, John Pino and II: p. 1164.
27. Kellogg Foundation, information provided by Gary W. King.
28. C. F. Kettering information provided by Marvin Lanborg.
29. Boyce Thompson Institute information provided by Richard Wellman.
30. Aldolph S. Clausi of General Foods Corp. testified on September 25, 1975, (II: p. 265) that the entire food industry spent $268 million on research and development in 1973, according to an NSF survey. This was the best available hard data on private industry support for food-related research presented during the hearings. The rest of the food-related research; i.e., for machinery, fertilizers, pesticides, was derived from table 6 of the article by H. L. Wilke and H. B. Sprague submitted for the record, II: pp. 1136–43. In this table, (II: p. 1140) the "interest" of the industry is listed at left. The results for 1975 are based on projections made by the industries themselves in 1967, in response to a survey. It was difficult to separate out the food-industry classes, but approximately $200 million could be attributed to these. This does not differ too greatly from the NSF estimate above, especially since the survey did not achieve 100 percent coverage. The other categories which should be added to the total for food-related research are: "chemicals"; part of the "chemicals, feed, food, pesticides and fertilizers" grouping; and part of the "machinery" grouping. This would add about $100 to $150 million to the $268 million mentioned above. Data on private industry efforts is extremely difficult to obtain. The ARI is presently conducting a new survey of R. & D. expenditures by industry and expects results to be available in 1976. The total of about $393 million shown on this table could be high or low by as much as $50 to $100 million and should therefore be considered as only an estimate.
31. Data for State government funding of agriculture research to SAES obtained from USDA, R. Alsmeyer and E. Davis. An estimate, provided by Alsmeyer, of about $0.5 million has been added for the Colleges of 1890. Only food-related research funding included.
32. Data for non-SAES universities obtained by adding up the amounts on the NSF list: Total Life Sciences Expenditures in Universities and Colleges . . . 1975; "Agricultural Sciences" and subtracting the federally

funded R. & D. for that same list of universities. Note that only the first 100 ranked universities (in order of funding) were used. The universities affiliated with SAES were not counted. This list did not break out non-food research; i.e., tobacco, cotton fiber, and so on. The list was provided by James Hoehn of the NSF. The non-SAES university funds identified in this survey as provided by non-Federal Government funding organizations, totaling 0.5 million were also subtracted from this figure. Note that some of the funding for non-SAES universities may be coming from private industry or from State/local governments. It was not possible to obtain data to break this out.

33. Universities counted: University of Washington, Harvard, Columbia University, Yale, Duke, Iowa State University of Science and Technology; Vanderbilt, University of Puerto Rico (Mayaguez), and University of Kansas.
34. MRI information provided by Charles Romine; fiscal year 1975 figures.
35. Not all nonprofit organizations performing agricultural research are covered here. Others would include Stanford Research Institute and the Food Institute (Chicago). Cooperatives often support agricultural research projects as well. These are usually financed by specific industries, however, and would therefore probably have been counted in the private industry category.
36. ARS may also give some grants to nonprofit institutions. They were not able to separate these out of the total figure of $0.745 million going to non-SAES universities.
37. Discussions with Howard Sprague of U.S. AID, who works with the ARI, indicated that most of the industry funding is going for their own R. & D. activities. The total of $393 million shown in table I has had approximately $25 million subtracted which goes to SAES. The total shown here probably accounts partially for the nonagreement between total funds and total research efforts in tables I and II since universities and nonprofit institutes may also be counting some of the same funds.
38. USDA, additional information from E. Miller.
39. Although some NSF funding does go to universities with SAES, it was stated that funding goes to the academic departments and does not have any impact on the research efforts of the SAES. This information obtained from Dillon of NSF.
40. It was not possible to get a complete listing of State appropriations to non-SAES universities since no organization or agency gathers this data. In 1975, however, the American Association of University Agricultural Administrators (AAUAA) surveyed 47 U.S. universities and colleges outside the land grant system which would be eligible for membership on the AAUAA. The list of institutions appears in Appendix C. They found that in 1975 agricultural research programs at these academic institutions totaled about $4.344 million of which $1.968 million came from State appropriations, $1.648 million came from the Federal Government, and $0.728 came from other sources, such as private industry. Dr. Jim Dollahon, dean of the College of Agriculture, University of Wisconsin (River Falls), and chairman of the AAUAA, provided this data. Note that work in nonagricultural departments, which may be food related, was not covered in this survey.
41. If an organization identified a funding recipient as an academic department outside the college of agriculture but within an SAES-affiliated university, this was counted as "non-SAES." For example, SE; ERDA gave a grant to the Civil Engineering Department at the University of Massachusetts to develop wind energy systems for farm homes. This was considered to be "non-SAES."
42. State and/or local governments may perform more research than is indicated here. For instance, some States maintain a "chemists office" which could perform agricultural research. There is no central listing of such research activities on the part of State and local governments.
43. This figure probably includes the $1.648 million reported by agricultural units in non-land-grant academic institutions as noted in footnote 40. Some food-related research also occurs in departmental units other than agriculture, therefore accounting for the higher figure of $15.228 million reported here.

Additionally, the NSF amounts have been kept separate since some of their grants may be to nonagricultural departments within land-grant universities. See footnote 39.

44. HEW, NIH; information provided by Dr. M. Mehlman. Estimates of intramural funding for food-related research were $15 to 20 million and $20 million is shown for NIH in-house research in table II. The designation of the remaining $33 million was not identified at the time of preparation of this report. We have chosen to place this amount in the "non-SAES affiliated universities" category since the NIH grants probably would go to academic departments such as physiology, chemistry, and so forth, separate from schools/colleges of agriculture.

45. Note that the totals shown in tables I and II do not cross-check exactly. This is probably due to double counting in some categories; that is, universities may have reported funds spent for research which had been provided through private industry grants. Private industries may also be counting these same funds as money spent for research. Such double counting could not be easily identified or avoided. These totals should therefore be treated as estimates to give the general picture for food-related research funding and performance in fiscal year 1976.

Note.—Abbreviations used in Tables I and II are listed at the front of this report, with the exception of the following:

APC	Agricultural Pollution Control Program (Environmental Protection Agency)
APM	Alternate Pest Management Program (Environmental Protection Agency)
BER	Biomedical and Environmental Division (Energy Research and Development Administration)
BTI	Boyce Thompson Institute
CFK	C. F. Kettering Foundation
EP	Effects of Pollutants Program (Environmental Protection Agency)
FF	Ford Foundation
FPI	Food Products Industry Program (Environmental Protection Agency)
HEE	Health and Ecological Effects Program (Environmental Protection Agency)
KF	Kellogg Foundation
MRI	Midwest Research Institute
NBS	National Bureau of Standards (Department of Commerce)
NOAA	National Oceanic and Atmospheric Administration
RF	Rockefeller Foundation
SE	Solar Energy Division (Energy Research and Development Administration)

The Department of Agriculture, perhaps surprisingly, received only about one-half of the Federal appropriations for such research, or 54 percent of the total Federal appropriations. Of the other executive agencies—Department of Health, Education, and Welfare with 11 to 12 percent, Department of State with 8 to 9 percent, Energy Research and Development Administration with about 7 percent, and Department of Commerce and National Science Foundation with about 6 percent each—it could be said that most of these research efforts could be considered mainly as food-related rather than direct agricultural or food research. Four other agencies—Department of the Interior, Department of Defense, Environmental Protection Agency, and Tennessee Valley Authority—also had smaller efforts in food-related research, dividing about 7 percent of the total Federal appropriations.

The appropriations from State governments went almost exclusively to the State Agriculture Experiment Stations at land-grant universities. Only about 1 percent of the total State appropriations available were identified as received by non-land-grant universities for agricultural research. It should be noted here, that information on the non-

land-grant universities was extremely difficult to obtain. These statements and the data shown in the tables and graphs are based on a survey taken in 1975 by the American Association of University Agricultural Administrators. Non-land-grant institutions had responded to that survey and identified the amount of funding received for agricultural research in 1975 from the States. It was assumed that the amounts would not have increased or decreased radically for 1976 in preparing this analysis. However, the possible funding by the States of food-related research in other than "agricultural" departments of non-land-grant universities, could not be identified. It was not possible to judge how extensive such appropriations might have been in 1976, so that the 1-percent figure shown should be considered as an estimate.

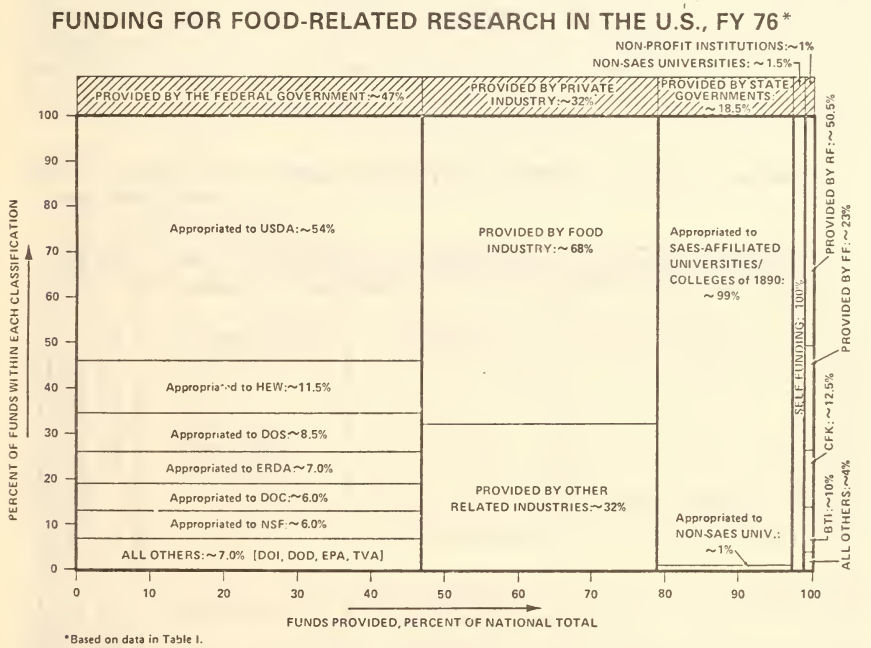

FIGURE 1.—Funding of food-related research in the United States, fiscal year 1976

This chart indicates the major classifications of fund providers for food-related research in the United States for fiscal year 1976. For the classifications, "Private industry," Nonprofit institutions," and "Non-SAES universities," the vertical distribution shows the major sources funds for each category. For the two Government classifications the distribution of appropriations from the total available is shown. This chart summarizes the data listed in table I.

Although the percentage of the total national funds available, which were supplied by nonprofit institutions, was small (less than 1 percent), these institutions play a significant role in the support of research for food production in developing countries (as does the Agency for International Development of the Department of State). Many of the international agricultural research centers described earlier could not have been established, nor could they continue their extensive research without the funding of these organizations. It was

also apparent from the funding information provided, that such organizations attempt to channel funds to disadvantaged domestic farmers, such as American Indians, for research in areas to meet their particular food needs.

The numbers shown for private industry should also be considered as estimates. Where possible, statements of witnesses, or material submitted for the record, were used to arrive at the totals shown. However, private industry does not participate in any regular information-gathering system, such as the Current Research Information System of the Cooperative State Research Service, so that firm and recent figures on their food-related research efforts were difficult to obtain. The footnotes which accompany table I, "Funding of Food-Related Research, FY 1976," explain the methods used to arrive at the estimate shown for private industry investment. Of the total shown for private industry, it was estimated that approximately 68 percent was supplied by the food industry itself, while the remainder came from food-related corporations; for example, fertilizer manufacturers, pesticide manufacturers, or machinery manufacturers.

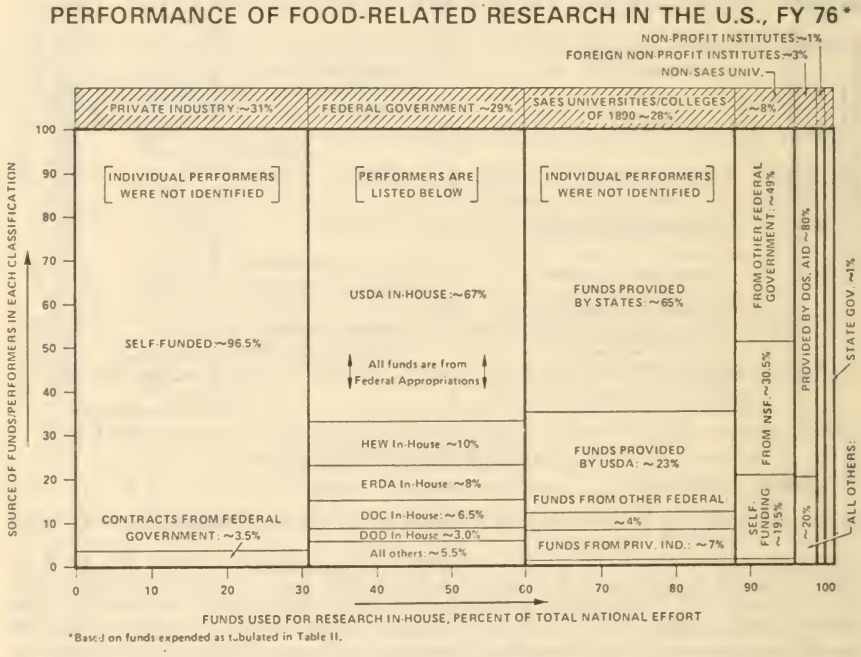

FIGURE 2.—Performance of food-related research in the United States, fiscal year 1976

This chart depicts the distribution of reported in-house food research efforts according to various performer classifications. For the performer classification, "Federal Government," the relative distribution of efforts among the various agencies is indicated on the vertical axis. For all other performer classes the sources of the funds utilized for intramural research programs are shown. This chart is based on the data listed in table II.

THE FEDERAL/STATE SYSTEM PERFORMS OVER 50 PERCENT OF THE FOOD-RELATED RESEARCH

Table II, "Performers of Food-Related Research, FY 76," and figure 2 indicate the division of actual food-related research efforts among major classifications of performers for fiscal year 1976. The data was derived from the amounts reported by the involved organizations as actually spent for in-house research. It can be seen from figure 2 that the performance of research is divided almost into thirds among three major classes of performers: private industry, about 31 percent; Federal Government, about 29 percent; and State Agricultural Experiment Station (SAES) universities/Colleges of 1890, about 28 percent. The non-SAES university system is responsible for about 8 percent of the effort, while foreign nonprofit institutions perform about 3 percent—in terms of U.S. supplied funds—and nonprofit institutions and State government agencies perform about 1 percent each.

Of the moneys utilized by the private sector for their food-related research efforts the major portion, 96–97 percent is obtained from self-funding. The private sector does receive 3–4 percent of its research funds from Federal contracts, as identified by individual agencies and shown in table II.

Of the amount of research funds spent in-house by the Federal Government, all appropriated, the major portion is utilized by the USDA, or about 67 percent. The other major performers in the Federal system are: Health, Education, and Welfare, utilizing about 10 percent; Energy Research and Development Administration, using 8 percent; Department of Commerce, utilizing 6–7 percent; and Department of Defense, with about 3 percent. The remainder is divided between Department of the Interior, Environmental Protection Agency, and Tennessee Valley Authority. Note that two providers of funds in the Federal system, National Science Foundation and Department of State do not have any in-house research capabilities in the food-related area.

The other large performing classification, SAES universities/Colleges of 1890, receives the major portion of its funding from State appropriations, or about 65 percent of total funds spent. The Federal Government provides the next largest portion, 27 percent, with the USDA accounting for 23 percent itself. See table II for the other Federal agencies reporting funding to SAES universities/Colleges of 1890. Private industry supplies the balance of the funding for this classification of performers, or about 7 percent.

The non-SAES universities received the bulk of their funding for food-related research from the Federal Government. The NSF provided about 23 percent of their funds, while other Federal agencies accounted for about 49 percent. Self-funding, in the form of tuition money, sales of goods from university farms, endowments and rotating funds, probably accounted for the remaining 19–20 percent. It is cautioned again that data on these universities were not readily available so a combination of methods was used to arrive at these figures and

interpretations. The footnotes to tables I and II should be consulted for the methodology used.

Of the U.S. funds going to foreign nonprofit institutions, 80 percent were supplied by the Agency for International Development of the Department of State. A variety of other contributors, mainly domestic nonprofit institutions, accounted for the remaining 20 percent.

The nonprofit institutions supported their research efforts almost totally with their own funds, although a small measure of funding was received in some instances from private industry and/or various Federal agencies.

The 1 percent figure shown for State governments consists entirely of funds transferred from the National Marine Fisheries Service, of the National Oceanic and Atmospheric Administration, in the Department of Commerce to the States for research work. It could not be ascertained whether such funds were actually utilized by State agencies or were transferred, in turn, to universities, or other performers. It is also possible that some States maintain research facilities, such as chemistry laboratories, and so forth, which have not been counted into this total of performance of food-related research. Information on individual agencies of State governments was not available from the hearings record, and could not be obtained from any other central location.

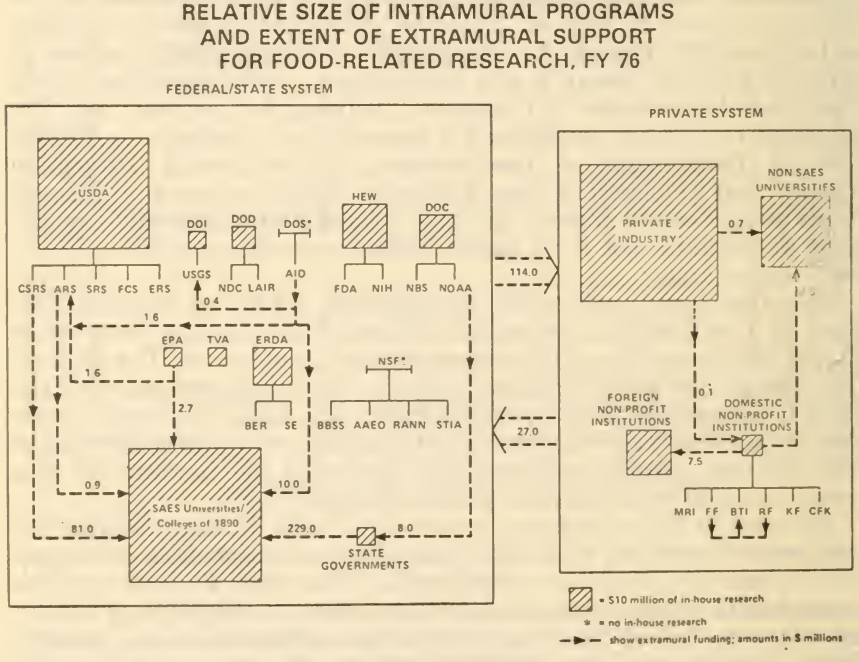

FIGURE 3.—Relative size of intramural programs and extent of extramural support for food-related research, fiscal year 1976.

The food research efforts of the United States have been divided into the Federal/State System and the Private System for purposes of this chart. Crosshatched blocks indicate the relative sizes of in-house (intramural) research programs for the individual organizations. Agencies marked with * do not perform

intramural food research. Small broken arrows indicate the transfer of funds for extramural support of research within each of the two systems. The large arrows show the extent of system-to-system transfer of funding. This chart is derived from the data in tables I and II.

NOTE.—Abbreviations used in this chart are listed at the front of this report, with the exception of the following:

AAEO	Directorate for Astronomical, Atmospheric, Earth, and Ocean Sciences (National Science Foundation)
BBSS	Biological, Behavioral and Social Sciences Division (National Science Foundation)
BER	Biomedical and Environmental Division (Energy Research and Development Administration)
LAIR	Letterman Army Institute of Research (Department of Defense)
NBS	National Bureau of Standards (Department of Commerce)
NDC	U.S. Army Natick Development Center (Department of Defense)
NOAA	National Oceanic and Atmospheric Administration
RANN	Research Applied to National Needs (National Science Foundation)
SE	Solar Energy Division (Energy Research and Development Administration)
STIA	Directorate for Scientific, Technological, and International Affairs (National Science Foundation)

INTERACTIONS AMONG FOOD-RESEARCH SYSTEMS/ORGANIZATIONS

There is a highly complex scheme of interactions among public research organizations, among private research organizations, and between the two major systems—that is, public and private. Figure 3 depicts these interactions graphically. The size of the blocks indicates the size of the in-house research programs. Thus, it is seen that the USDA, private industry and the SAES all have fairly large and fairly equal blocks. The small arrows indicate the transfer of funds for research intramurally. The large arrows indicate transfer of funds from public to private and the reverse. Neither the individual donors, nor the individual receivers are depicted for these system-to-system transfers; however, this information may be derived from table II.

QUALIFICATIONS OF TABLES AND FIGURES

During the hearings one member of the private sector thought that "perhaps 50 percent of the research conducted is done by private enterprise. . . ." (II: p. 483) although the best data available, which is presented here, indicates that the private sector conducts about one-third of the food-related research. As mentioned earlier in this report, another witness had relied on a 1967 Agricultural Research Institute survey (which had included projections by the survey conductors for more than two-thirds of the private organizations which had not responded) to state that "roughly 50 percent of the total research capability was represented by the private industry." Later testimony from a food industry representative (II: p. 265) indicated that such projections may have been too high. He noted that in 1973 the food industry investment had been $268 million. This figure matched fairly well with the projections shown for 1975 in the ARI study for just the respondents to the survey. Therefore, for purposes of this analysis, it was difficult to adopt the ARI projections of triple that figure, which had been obtained by estimating the possible research level for the nonrespondents to their survey.

An interesting contrast can be seen in the total budget for food-related research for the Federal Government tabulated by the Federal

Council on Science and Technology in their report on the Federal R. & D. program for fiscal year 1976. The section relating to food research is bound into the hearing record (II: pp. 1021–1027). On page 1027 of this document it is stated that the total Federal Government research program for food in fiscal year 1976 totaled about $367 million. This does not agree with the total shown in table I for research funding by the Federal Government, which is almost $585 million. The total in-house research effort of the Federal Government in this area, however, does total about $350 million.

SPECIFICS OF FUNDING—FEDERAL AGENCIES

The methods used to distribute funds by the USDA, especially the Cooperative State Research Service (CSRS), and by the National Science Foundation generated considerable commentary during the hearings.

The authority under which the CSRS grants most of its research funds is the Hatch Act of 1887, amended in 1955. (See chronology of agricultural research events, Appendix A to this report.) Dr. Thomas Ronningen, Associate Administrator of CSRS, explained the authorities embodied in this Act:

> It shall be the object and duty of the State agricultural experiment stations through the expenditure of the appropriations hereinafter authorized to conduct original and other researches, investigations and experiments bearing directly on the contributing to the establishment and maintenance of a permanent and effective agricultural industry of the United States, including researches basic to the problems of agriculture in its broadest aspects.
>
> . . . It is further the policy of the Congress to promote the efficient production, marketing, distribution, and utilization of products of the farm as essential to the health and welfare of our peoples and to promote a sound and prosperous agriculture and rural life as indispensable to the maintenance of maximum employment and national prosperity and security. It is also the intent of Congress to assure agriculture a position in research equal to that of industry, which will aid in maintaining an equitable balance between agriculture and other segments of our economy. (II: p. 130)

Material submitted for the record by Ronningen (II: p. 132) indicated that Hatch Act payments to States estimated for 1976 would total about $83.6 million. Later information indicated that some $67 million of this was for food-related research. Since the total food research budget of the CSRS was identified to be $81.083 million for fiscal year 1976, this would indicate that about 80 percent of the CSRS budget which is obligated to this type of research goes directly to the State Agricultural Experiment Stations (SAES) in formula grants. The control of these funds lies with the States as Dr. Orville Bentley explained in material submitted for the record:

> The priorities of use of the Hatch formula funds are determined by people in the States—the State agriculture experiment station director and his staff. CSRS reviews all proposals to see that they meet legislative requirements and they are of acceptable quality; beyond this the direction of the use of the funds rests with the agricultural experiment station director. (I: p. 199)

Formula grants are also provided to the Colleges of 1890 under the Public Law 89–106 research grants program. These grants are similarly noncompetitive in nature, and totaled approximately $8 million in fiscal year 1976 for food-related research activities. The CSRS total budget, for fiscal year 1976, then was comprised of approximately

$75 million, or more than 90 percent, formula grants—over which it had no control, other than administratively.

Competitive grants are also made by the CSRS under the provisions of Public Law 89–106. In this case, targets and goals are set in areas where it is felt that research is particularly needed to meet national needs. This process is carried out in consultation with the Agricultural Research Service. In fiscal year 1976, the following subject areas were stipulated for the competitive grant program: Environmental quality; food and nutrition; beef and pork production; soybeans; pest management; transportation; forage, pasture, and range; and genetic vulnerability. Of these, only the environmental quality grouping would be considered nonfood research. The CSRS sends out a list of these programs and the amounts available in grants [1] for each area to interested universities and all SAES.

Another concern expressed during the hearings was over the manner in which the competitive grants program was administered by the CSRS. For instance, the number of proposals which any institution may submit under this program in a year is limited to five. (I:p. 200) These may be divided as the institution sees fit, with a limit of two in a subject area. In any case, an institution could only possibly submit research proposals in a maximum of 50 percent of the subject areas chosen for 1976, due to this restriction. CSRS uses a peer panel to rate each proposal received, and Bentley explained:

> If two proposals received from an institution received a rating higher than proposals from other institutions within the same category, both would be funded. However, if two proposals from one institution in a category received the same ranking as one from another institution, it has been CSRS policy to fund one proposal from each institution. This procedure, when grants are funded at an adequate level, permits the expertise of two institutions to be focused on a problem instead of having a more concentrated effort on a problem by the expertise maintained by one institution.
>
> The agency's policy has been to award grants only to those institutions where it feels research there has the highest feasibility of achieving the objectives of the proposed project. (I : p. 200)

Although CSRS does not exclude the participation of non-land-grant universities, in fiscal year 1976 only four such institutions received grants under the competitive program [2] so that, in fact, better than 99 percent of CSRS funds available for food-related research in 1976 went to the SAES/Colleges of 1890.

One other aspect of the Public Law 89–106 funding program bears examination. In some instances there has been a predesignation by Congress as to what these funds are to be used for, and to whom the grants were to be given. CSRS pointed out that such "earmarking" is sometimes consistent with their own views of the research needed to meet national needs. For instance, in 1966 a special grant for soybean research was originated in Congress. However, in 1976 the land-grant community chose soybeans as a program of national need. Of the $5.44 million available in the special grants program

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[1] A letter from Dr. Elizabeth Y. Davis, coordinator of Home Economics Research, USDA, CSRS, dated June 15, 1976, confirmed that the following amounts were made available in fiscal year 1976 in the seven food-related research areas: Food and nutrition, $0.94 million; beef and pork production, $1.5 million; soybeans, $0.5 million; pest management, $0.5 million; transportation, $0.5 million; forage, pasture and range, $1 million; and genetic vulnerability, $0.5 million. Total available: $5.44 million.

[2] University of Texas, University of Southern Illinois, University of Pennsylvania, and University of Colorado, for a total of about $0.346 million of the $5.44 million available.

for fiscal year 1976 the following amounts had been predesignated by Congress: in the food and nutrition area, $0.15 million for food and agricultural policies and $0.075 million for taro research; in the beef and pork production areas, $0.075 million for Lone Star tick research; and in the forage, pasture, and range area, $0.2 million for a study of soil erosion in the Pacific Northwest. Thus, of the total special grants funds available in fiscal year 1976, about 9 percent had been earmarked by the Congress.

The small portion of remaining CSRS funds are provided under Title V of the Rural Development Act of 1972. Such grants are governed by procedures and regulations similar to those for the Hatch funds. (II: p. 131)

The preceding discussion would seem to indicate that the CSRS has very little control over the research priorities for about 94 percent of the funds it administers for food-related research.

Funding for such other USDA agencies as the Agricultural Research Service (ARS), Farmer Cooperative Service, Economic Research Service, and Statistical Research Service, is provided directly through congressional appropriations, and must relate to USDA missions. Each of the agencies develops a budget, submits it to USDA management, which in turn, submits its total budget to the Office of Management and Budget (OMB), and to the appropriate congressional committees when finalized.

It was mentioned earlier in this report that the ARS is divided into regions. The regional administrators play an important role in the budgetary process for the ARS since they receive a continuous flow of proposals for research. After evaluation, the regional administrators may include such proposals in their own budget suggestions to the ARS. In this way, there is at least a partial local influence on the research directions taken by the ARS. The ARS also receives some "pass-through" funds for research from other Federal agencies; for example, the Energy Research and Development Administration and the Environmental Protection Agency.

The National Science Foundation (NSF) makes a significant number of competitive grants for programs relating to agricultural sciences. They have a well-developed system of peer review, and stated that they require "cost-sharing" on their grants. This could be a contribution on the part of a university, for example, of the researcher's time to be devoted to the research work. The NSF rarely gives grants to commercial or other private sector profit making organizations, although they do not have a policy against this practice. It was also stated that NSF grants go to the regular academic departments within universities, not to agricultural experiment stations. One witness pointed out during the hearings that less than one-third of the NSF grants which they had deemed relevant to agriculture in 1974 had actually gone to agricultural scientists. (II: p. 425) Dr. Glenn Pound, Dean of the College of Agriculture and Life Sciences, University of Wisconsin, suggested that trend was probably still apparent today in the NSF grant system for agricultural-related research.

Within the Department of Commerce, the National Oceanic and Atmospheric Administration (NOAA) receives most of the funds it utilizes for food-related research through direct appropriations. However, a permanent appropriation is also used which is transferred yearly from the Agricultural Marketing Service of the USDA. This funding is in the amount of 30 percent of the customs receipts collected annually on fisheries products. NOAA makes grants from its appropriations and from this special fund to private industry, universities, and to nonprofit institutions for research related to food.

All of the other Federal agencies performing food-related research receive most of their funds through the regular appropriation processes.

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